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DOE/NASA CONTRACTOR
REPORT

DOE/NASA CR-161538

SOLAR ENERGY SYSTEM DEMONSTRATION PROJECT AT WILMINGTON SWIM SCHOOL, NEW CASTLE, DELAWARE - FINAL REPORT

Prepared by

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George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy

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U.S. Department of Energy

Solar Energy

I. Table of Contents

BUILDING AND SYSTEM SURVEY

BUILDING

The solar system is for the Wilmington Swim School, New Castle, Delaware. A major addition, now completed extends the building to 20,650 gross square feet; 12,400 square feet in the existing building, 8,250 in the addition. Construction of the existing building was carried out in 1964. The addition was completed during the summer of 1979. Primary building systems are masonry exterior wall, precast concrete floors, laminated timber roof framing with wood roof decking. Conventional wood framing is used in some areas. Both asphalt shingles and built-up roofing are utilized. The building is heated by a gas fired hot water system. Cooling, limited to a very small area of the building, is done by standard air conditioning units.

The Wilmington Swim School presently serves the entire Wilmington metropolitan area with instructional and competitive aquatic programs. It frequently accommodates major area swimming meets. The expansion of the facility provides the school with large general exercise rooms, sales and administrative spaces, a teaching and therapeutic pool, a health spa, additional locker rooms, etc. Concurrent with the expansion there were modifications to the mechanical system to improve efficiency.

The Wilmington Swim School is located near the interchange between Interstate 95 and a major county arterial, New Castle Avenue. The site is bounded by the interchange and the arterial, a moderate income single family subdivision and a motel and restaurant complex. The land immediately surrounding the school is flat and paved for parking.

SUMMARY OF SOLAR SYSTEM

The active solar system is composed of 2,500 square feet of Revere Sun-Aid Collectors, model 332, having a single special low iron glazing and a black chrome selective surface. The collectors are arranged in seven (7) banks and are piped to a 3,600 gallon concrete tank located adjacent to the building. The tank is insulated to R=30 and buried in a stone lined pit fitted with a french drain and sump. A microcomputer based control system selects the optimal application of the stored energy among space, domestic water and pool heating alternatives. Selection is based on seasonal energy availability and the specific thermal requirements of each load. For example, if winter space heating requires water temperatures in excess of 120 degrees F., stored water below 120 degrees F. will be used for pool heating which only requires

BUILDING AND SYSTEM SURVEY (Continued)

temperatures in excess of 85 degrees F. Further, any heat stored at temperatures below 85 degrees F. may be used for domestic water pre-heating. During the summer months, stored heat will be used for domestic water and pool heating. Under these conditions, efficiency will be maximized throughout the entire year.

A vertical wall passive collection system was constructed as part of the new addition. The 256 square foot system will provide approximately 25 percent of the heated fresh air requirements for the office area.

As the control system is presently programmed, needs will be served in the following order:

1. space heat - new addition
2. domestic water - entire facility
3. pool heating - entire facility

Assuming we satisfy space heating completely before going on to the next load, to satisfy domestic water needs completely before pool heating, the active system will yield 67% of the space heating requirements, 61% of the domestic water requirements and 20% of the pool heating requirements. Overall, the active system will supply 20% of the entire thermal energy needs of the Wilmington Swim School.

These estimates are derived from F-chart values containing the following assumptions:

a. Control system priorities were space heat, domestic water, and pool heat. Energy was diverted only upon complete satisfaction of the higher priorities.

b. Building was maintained at constant temperature.

c. Other energy conservation procedures, e.g. night setback dehumidification, pool covering, heat recovery, etc. are not considered.

d. The entire collector bank oriented at 30 degrees west of South. In reality, 25 percent of the bank faces directly South.

e. The passive system has not been included.

When the passive and heat reclamation systems are considered, total building load is reduced over 30 percent. Specifically, the pool area dehumidification recovery system reduces annual system load by 166.3×10^6 BTU. The stack heat recovery system produces

BUILDING AND SYSTEM SURVEY (Continued)

317×10^6 BTU on an annual basis. Heat reclaimed from the boiler stack is dumped to storage or domestic water depending on system conditions.

From an economic perspective, the solar system is replacing BTU's currently obtained at $3.79 per million. However, natural gas availability is subject to question for non-essential users. During the winter of 1977, the local gas utility proposed to substantially cut or even eliminate the Wilmington Swim School's gas allocation. If natural gas becomes unavailable, the Swim School would have to cease operations or convert to an alternative fuel. Practically speaking, the most reasonable alternatives are propane, oil and electricity, all of which are priced substantially more than gas.

Under the alternative of electricity, the active solar system will save $11,000 per year ($16.11 per million BTU). At present gas prices, the solar system saves $3,740 per year. The fuel cost of the remaining alternatives is somewhere between. Without having access to the future, the most conservative strategy is to save every BTU possible.

Given the varied temperature requirements of the existing mechanical systems, virtually every BTU collected can be utilized. Therefore, one may view the critical issue as dollars available rather than dollars per BTU available. The 2,500 square foot active system represents the maximum collector area available on the existing and new roofs without substantial design modification. As such, it represents the upper limit of system performance and cost effectiveness.

3.

ACCEPTANCE TEST PLAN
WILMINGTON SWIM SCHOOL

Note all deviations from design drawings and specifications.

I. Collection performance and installation

A. Perform pressure test on collection subsystems.

1. Inspect headers RPW

2. Inspect silicone tubing and clamps RPW

3. Inspect collector inlet and outlet connections RPW

4. Inspect air vents, vacuum relief valves RPW

B. Test drain down.

1. Check drain down valve operation RPW

C. Inspect all mounting hardware, check collector and pipe support stability.
-Rust on pipe support hardware
-Galvanized/Aluminum contact on pipe supports RPW

D. Inspect plumbing-check head and flow or pumps. RPW

E. Inspect all insulation. RPW

F. Perform collection tests.

1. Collection with no loads RPW

2. Collection with loads RPW

3. Individual collector flow and temperature rise RPW

G. Perform passive subsystem evaluation.

1. Compare installation to design drawings RPW

2. Inspect quality of work RPW

3. Inspect control system and performance test RPW

4. Verify bypass vent operation RPW

RPW - ROBERT WEBER, SOLAR ENERGETICS, INC

II. Storage performance and installation

A. Inspect installation details.

1. Support slab RPW
2. Tank orientation RPW
3. Insulation RPW
4. Water proofing RPW
5. Back fill/drainage provisions RPW
6. Sump pit RPW
7. Heat exchanger mounting RPW
8. Interior tank coating RPW
9. Top door RPW

B. Inspect and note tank connections.

1. Heat exchanger piping RPW
2. Inlet and outlet piping RPW
3. Sensor mounting and wiring RPW
4. Fill valve operation RPW
5. Sump Pump and level alarm RPW

C. Determine storage performance.

1. Measure no-load 12 hour temperature Temperature drop - 1° F./24 Hrs. RPW
2. Calculate BTU loss - 1250 BTUH @ 110° F. RPW
3. Determine storage insulation valve - R-22 (with no insulation on tank lid). RPW
4. Determine storage stratification (thermal) 3.0 → 3.75° F. stagnant, 10° F. Dynamic. RPW

III. Load Distribution

A. Piping verification.

1. Location and sizing of pipes RPW
2. Valve, pump, iterface locations and orientation RPW
3. Insulation quality, freeze protection RPW

B. Check valve operation.

1. Mode RPW

2. Seating RPW

C. Check pump performance.

1. Head Pressure RPW

2. Flow Rate RPW

D. Heat exchanger effectiveness.

1. Measure heat exchanger flowrate RPW

2. Measure inlet and outlet, storage temperatures RPW

3. Calculate heat exchanger transfer rate RPW

4. Compare with design values RPW

E. Determine storage to load performance.
All loads are adequately heated. RPW

F. Determine auxillary heating performance. RPW

IV. Controls

A. Inspect installation.

1. Location of control panel, quality of hardware RPW

2. Location of sensors, valves, relays RPW

3. Wiring quality RPW

B. Check controller operation.

1. Collection RPW

2. Drain down RPW

3. Stack heat reclaim RPW

4. Domestic hot water RPW

5. Load performance (solar/back up) RPW

6. Check all pumps and valves for correct operation. RPW

C. Check fail-safe conditions.

1. High limit, low limit RPW

2. Power failure RPW

a. drain down RPW

b. digital data storage retention RPW

c. stability of micro processor RPW

1. on power loss RPW

2. on power resumption RPW

D. Check all sensors.

1. Temperature RPW

2. Flow rate RPW

3. Space controls (thermostats) RPW

E. Check data storage valves to calculated valves. RPW HI TEMPS. INVALID

F. Assure no oscillation or fluttering. RPW

V. Acceptance of installation and performance

A. Estimate fuel savings based on measured performance. RPW

B. Compare estimated to designed fuel savings. RPW

C. Determine system optimization and fine tuning. RPW

D. Inspect for growth of algae, mildew, fungi, mold. RPW

E. Measure current and voltage of all fans, pumps, controls. RPW

1. SPR-Racked collector pump
220 V. @ 4.1 A. = 902 W.

2. SPF-Flush collector pump
220 V. @ 6.6 A. = 1452 W.

3. SP3-Load-loop pump
220 V. @ 3.6 A. = 792 W.

4. SP4-Breech heat reclaim pump
110 V. @ 1.2 A. = 132 W.

5. Controls - 250 VA. maximum
No other electrical loads pertain to the solar collection or distribution system.

AS-BUILT DRAWINGS

AS-BUILT DRAWINGS

Figure	Description
1	Component takeoff
2	Collector layout & piping scheme
3	Solar schematic/mechanical interface
4	Roof plan/collector locations
5	Details - Collector mounting/pipe supports, storage unit
6	Storage tank location
7	Section through storage tank
8	Collector drawing (active)
9	Collector drawing (passive)

Fig. 1

WILMINGTON SWIM SCHOOL SOLAR SYSTEM COMPONENT TAKEOFF

NO.	QUAN.	DESCRIPTION
SP1 (SPF)	1	SOLAR PUMP B&G 60-17 1hp. 40' @ 44 gpm
SP2 (SPR)	1	" " " 60-16 3/4hp. 40' @ 16 gpm
DV1	1	MOTORIZED VALVE N/O 2" Honeywell V51B
DV2	1	" " " 1-1/2" " "
LL1	1	LIQUID LEVEL CONTROL 3/4" McDonnell NO. 27W
SP3	1	SOLAR LOAD PUMP B&G PD37 3/4hp. 30' @ 80gpm
V3B	1	V5045 HONEYWELL 2-WAY MOTOR VALVE 1-1/2"
V3B'	1	" " " " " "
V3S	1	" " " " " "
V3S'	1	" " " " " "
V5B	1	" " " " " "
V5B'	1	" " " " " "
V5S	1	" " " " " "
V5S'	1	" " " " " "
V6B	1	" " " " " 1-1/4"
V6B'	1	" " " " " "
V6S	1	" " " " " "
V6S'	1	" " " " " "
V7B	1	" " " " " "
V7B'	1	" " " " " "
V7S	1	" " " " " "
V7S'	1	" " " " " "
V4S	1	V8044A-1044 HONEYWELL DIVERTING VALVE 3/4"
V4B	1	V5045 HONEYWELL 2-WAY MOTORIZED VALVE 1-1/2"
SP4	1	GRUNDFOS UPS 20-64 1/12hp.
HX1	1	CENTRAL WATER HEATER HT. EXCH. 16-180 2-1/2"
HX2	1	" " " " " 6-70 1-1/2"
HX3	1	" " " " " 2-24 3/4"
HX4	1	COIL CO. 4 ROW-8 FIN/INCH 18" x 18" CARBON ST.

Fig. 2

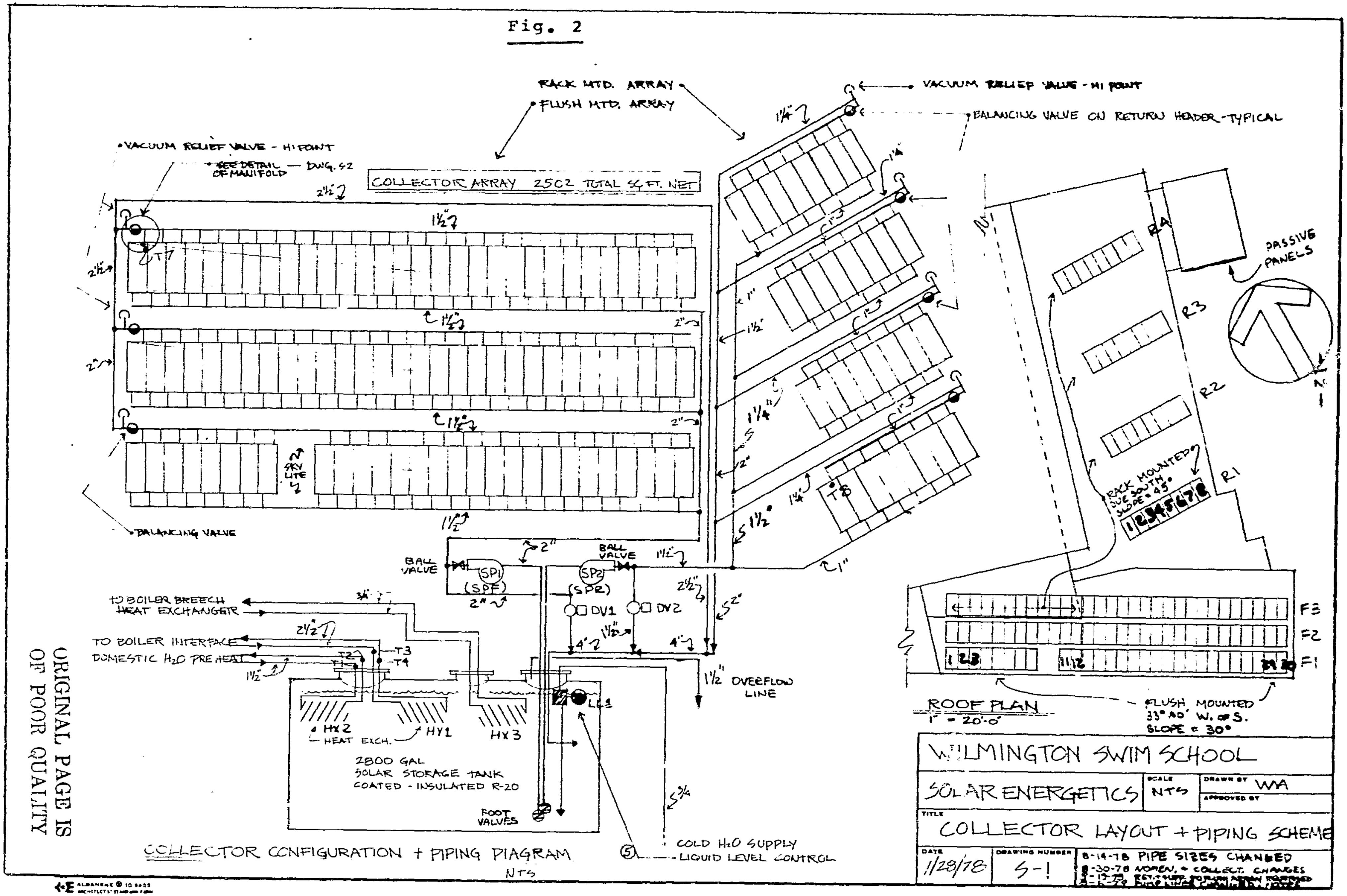
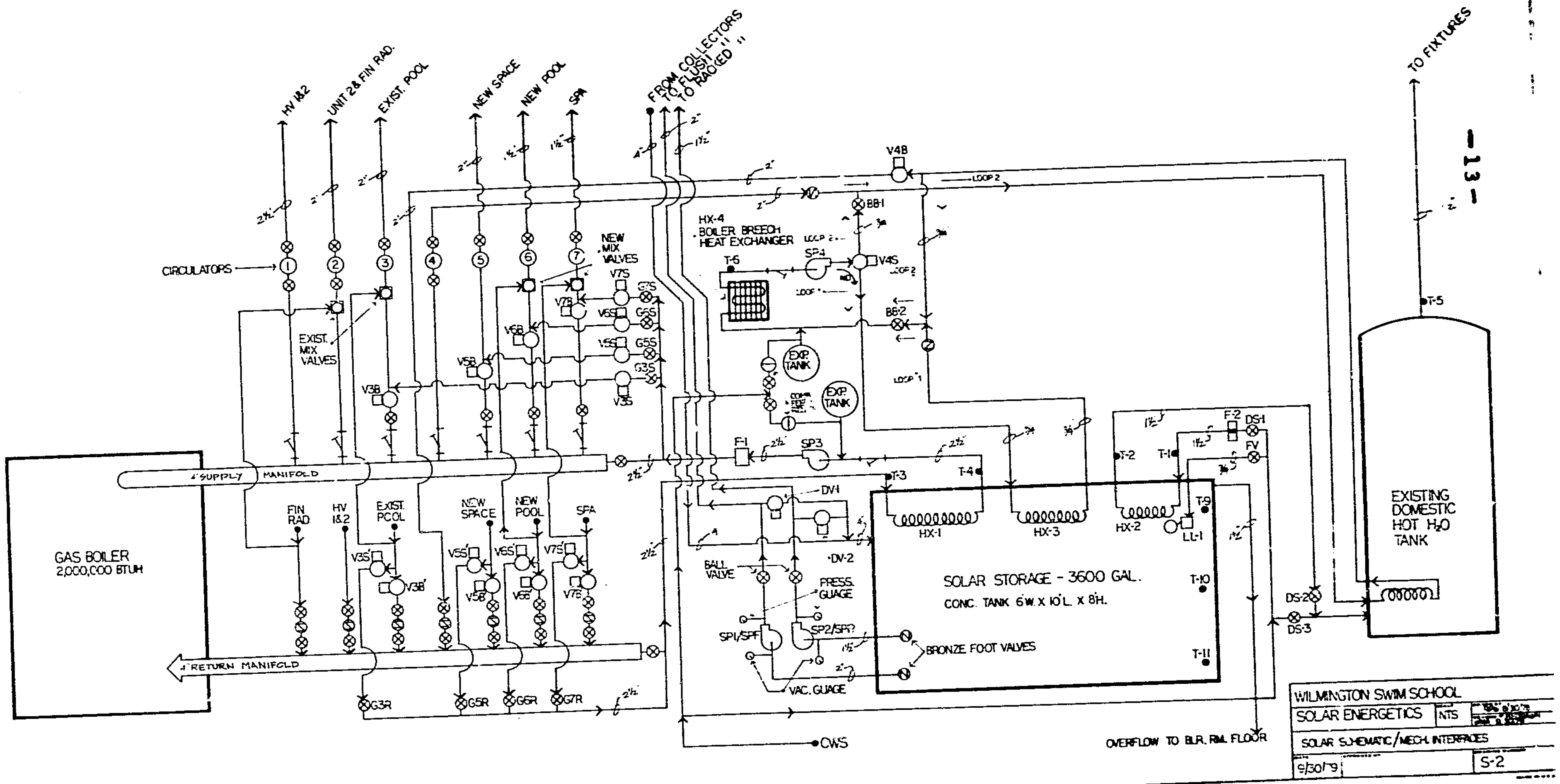

RACK MTD. ARRAY
FLUSH MTD. ARRAY
VACUUM RELIEF VALVE - HI POINT
BALANCING VALVE ON RETURN HEADER - TYPICAL
VACUUM RELIEF VALVE - HI POINT
SEE DETAIL OF MANIFOLD — DWG. S2
COLLECTOR ARRAY 2502 TOTAL SQ. FT. NET
SKY LITE
BALANCING VALVE
BALL VALVE
SP1
(SPF)
SP2
(SPR)
DV1
DV2
TO BOILER BREECH HEAT EXCHANGER
TO BOILER INTERFACE
DOMESTIC H2O PRE HEAT
T1
T2
T3
T4
T7
T8
1½" OVERFLOW LINE
HX2
HEAT EXCH.
HY1
HX3
LL1
2800 GAL SOLAR STORAGE TANK COATED - INSULATED R-20
FOOT VALVES
COLD H2O SUPPLY
LIQUID LEVEL CONTROL
PASSIVE PANELS
RA
R3
R2
R1
RACK MOUNTED DUE SOUTH SLOPE = 45°
F3
F2
F1
ROOF PLAN
1" = 20'-0"
FLUSH MOUNTED 33°40' W. of S. SLOPE = 30°
COLLECTOR CONFIGURATION + PIPING DIAGRAM
NTS
WILMINGTON SWIM SCHOOL
SOLAR ENERGETICS
SCALE NTS
DRAWN BY WA
APPROVED BY
TITLE
COLLECTOR LAYOUT + PIPING SCHEME
DATE 1/28/78
DRAWING NUMBER S-1
8-14-78 PIPE SIZES CHANGED
8-30-78 NOMEN. + COLLECT. CHANGES

Fig. 3



HV 1&2
UNIT 2 & FIN RAD.
EXIST. POOL
NEW SPACE
NEW POOL
SPA
FROM COLLECTORS
TO FLUSH "
TO RADGED "
TO FIXTURES
CIRCULATORS
EXIST. MIX VALVES
NEW MIX VALVES
HX-4 BOILER BREECH HEAT EXCHANGER
EXP. TANK
LOOP 1
LOOP 2
GAS BOILER 2,000,000 BTUH
SUPPLY MANIFOLD
RETURN MANIFOLD
FIN RAD
HV 1&2
EXIST. POOL
NEW SPACE
NEW POOL
SPA
BALL VALVE
PRESS. GUAGE
VAC. GUAGE
BRONZE FOOT VALVES
SOLAR STORAGE - 3600 GAL.
CONC. TANK 6'W. X 10'L. X 8'H.
HX-1
HX-3
HX-2
EXISTING DOMESTIC HOT H_2O TANK
CWS
OVERFLOW TO BLR. RM. FLOOR
WILMINGTON SWIM SCHOOL
SOLAR ENERGETICS
NTS
SOLAR SCHEMATIC/MECH. INTERFACES
9/30/79
S-2

Fig. 4

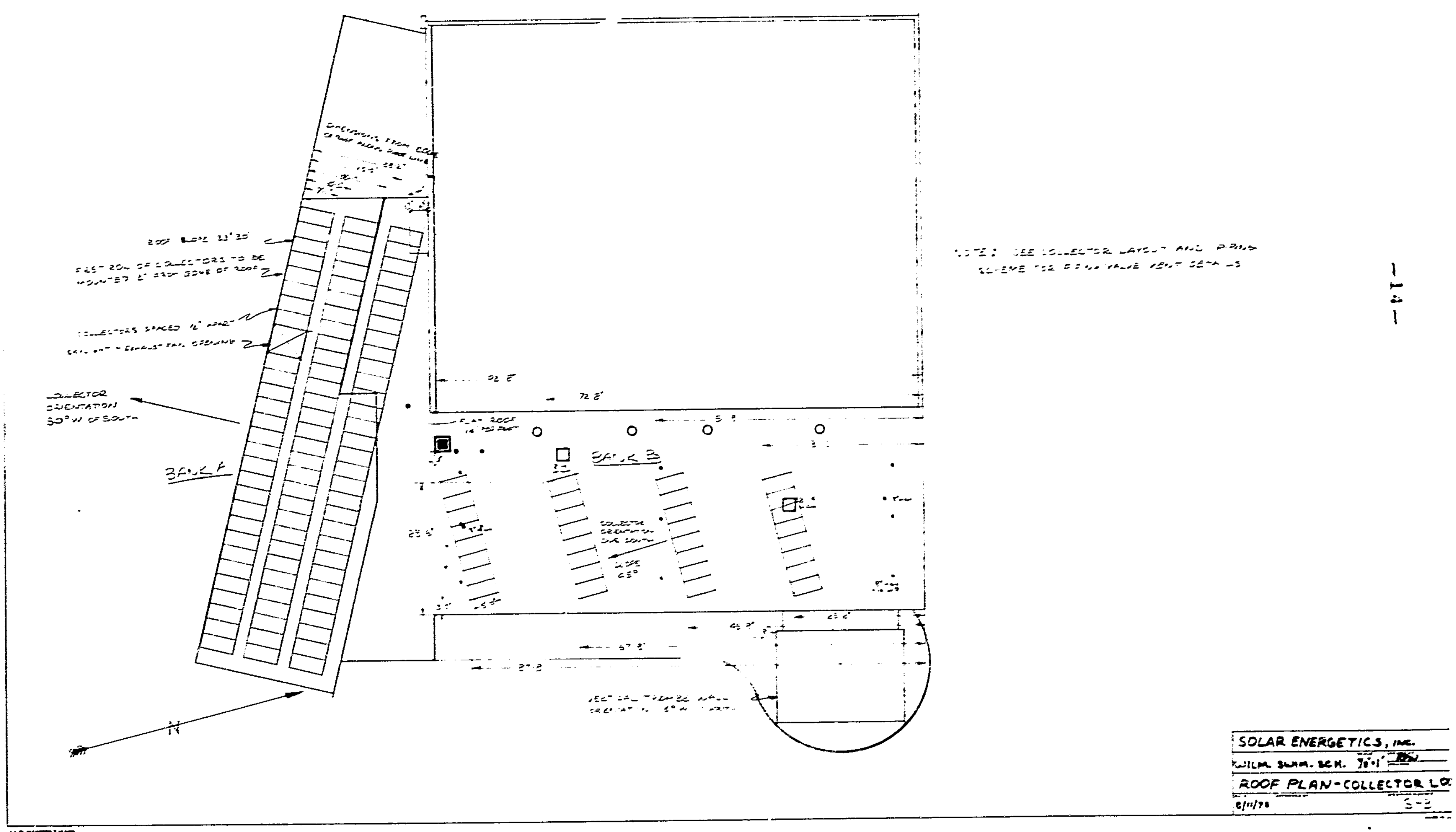

COLLECTOR ORIENTATION 30° W OF SOUTH
BANK A
BANK B
N
SOLAR ENERGETICS, INC.
ROOF PLAN-COLLECTOR LO

Fig. 5

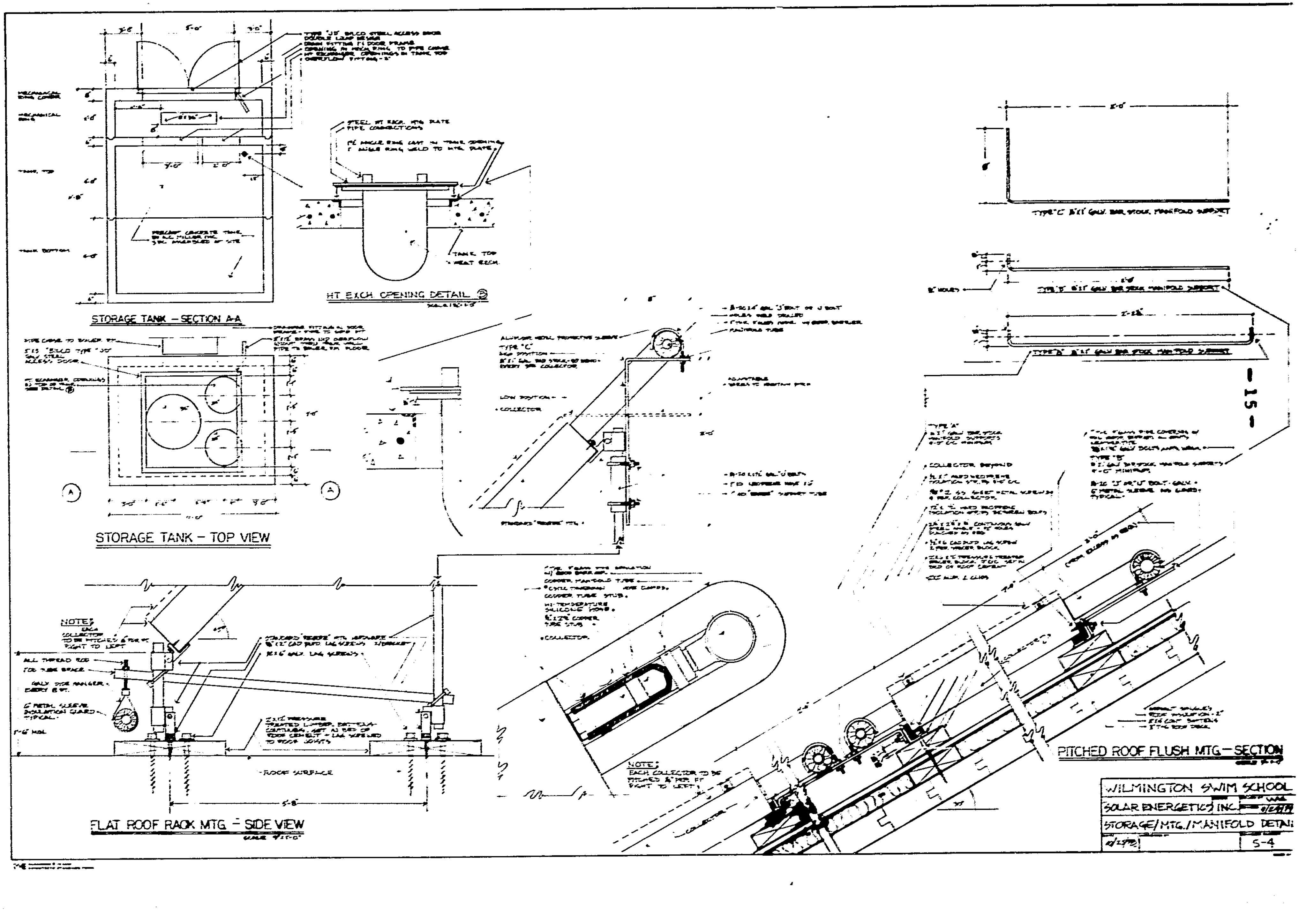
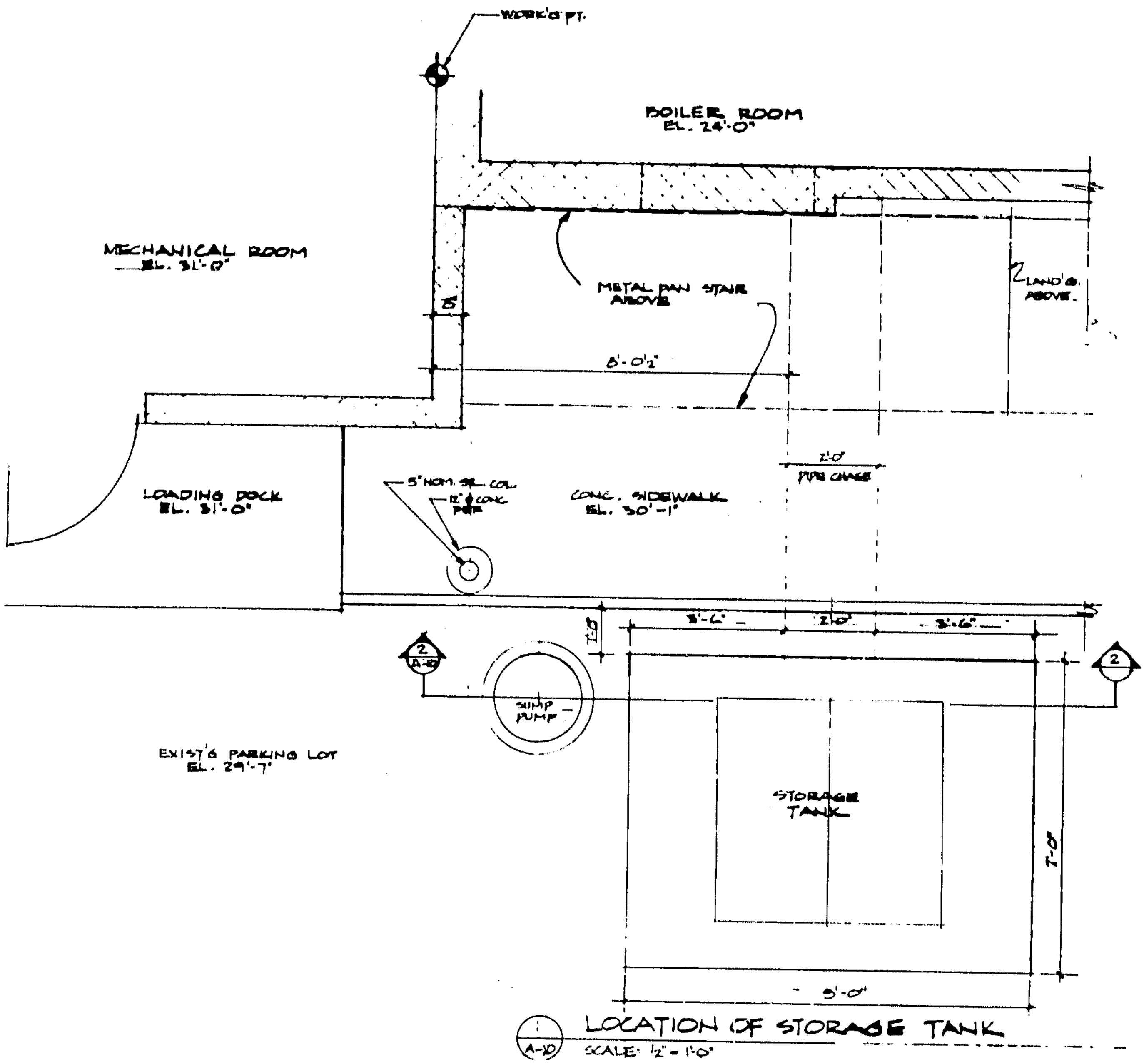

STORAGE TANK – SECTION A-A
HT EXCH OPENING DETAIL
STORAGE TANK – TOP VIEW
FLAT ROOF RACK MTG – SIDE VIEW
PITCHED ROOF FLUSH MTG – SECTION
NOTES:
NOTE:
ROOF SURFACE
WILMINGTON SWIM SCHOOL
SOLAR ENERGETICS INC.
STORAGE/MTG./MANIFOLD DETAIL
S-4

Fig. 6



LOCATION OF STORAGE TANK
SCALE: ½" = 1'-0"

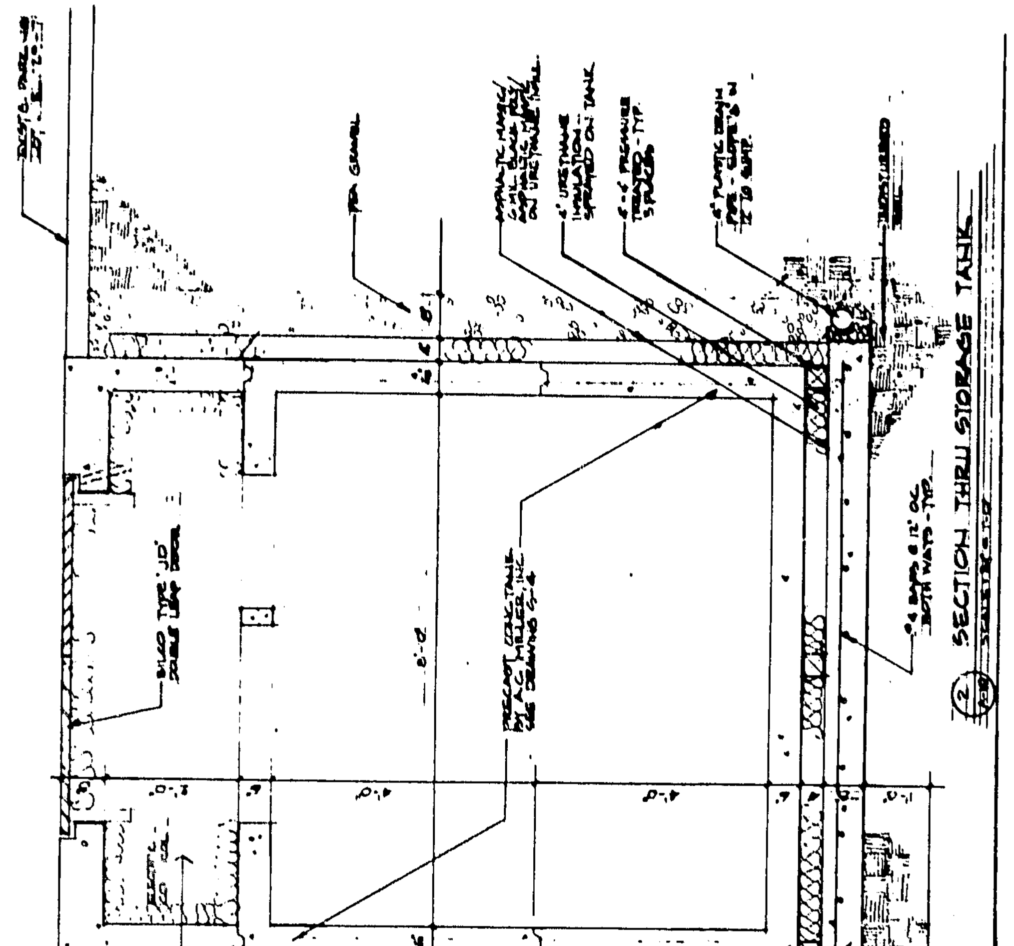


Fig. 7

Fig. 8

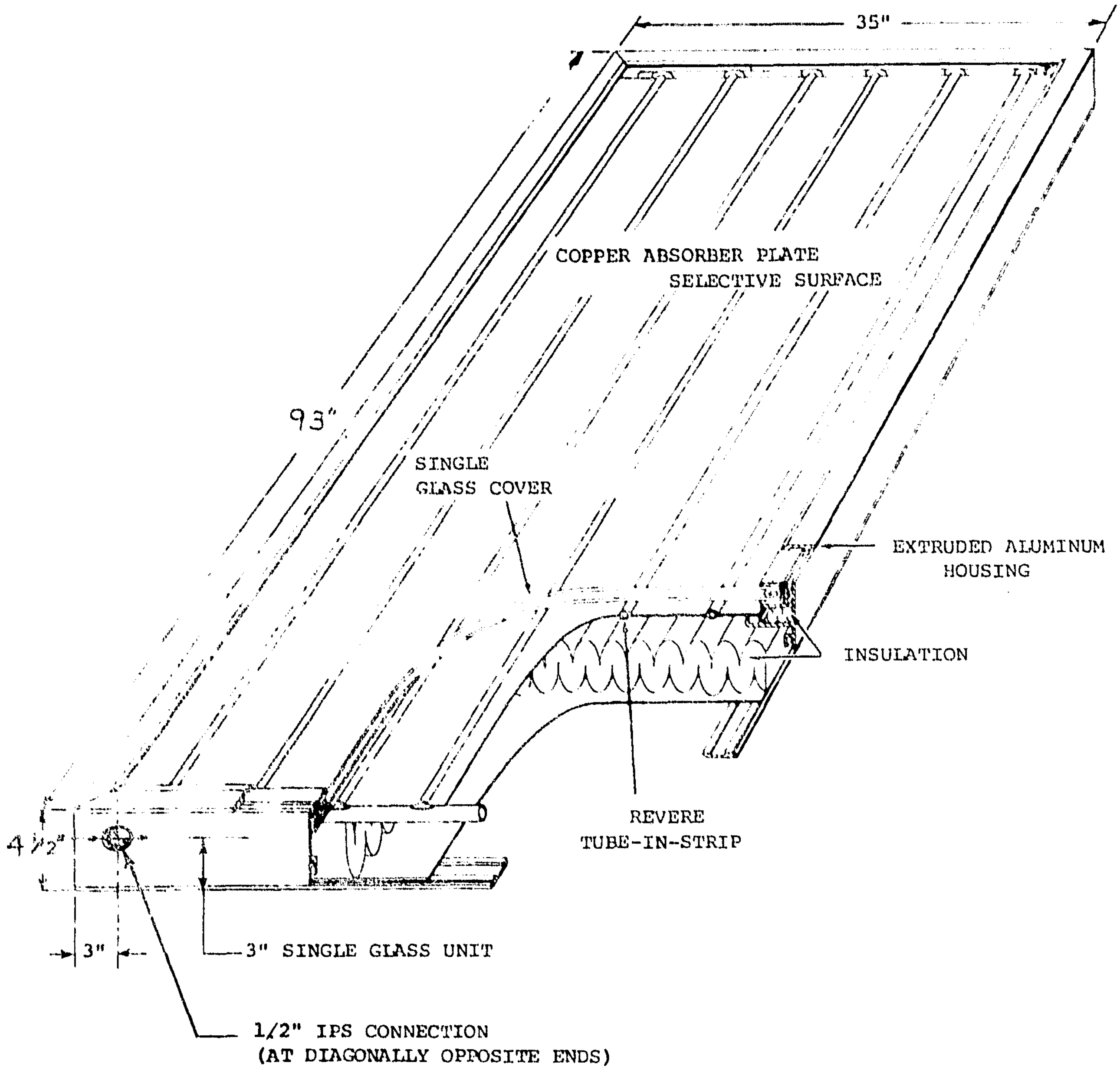
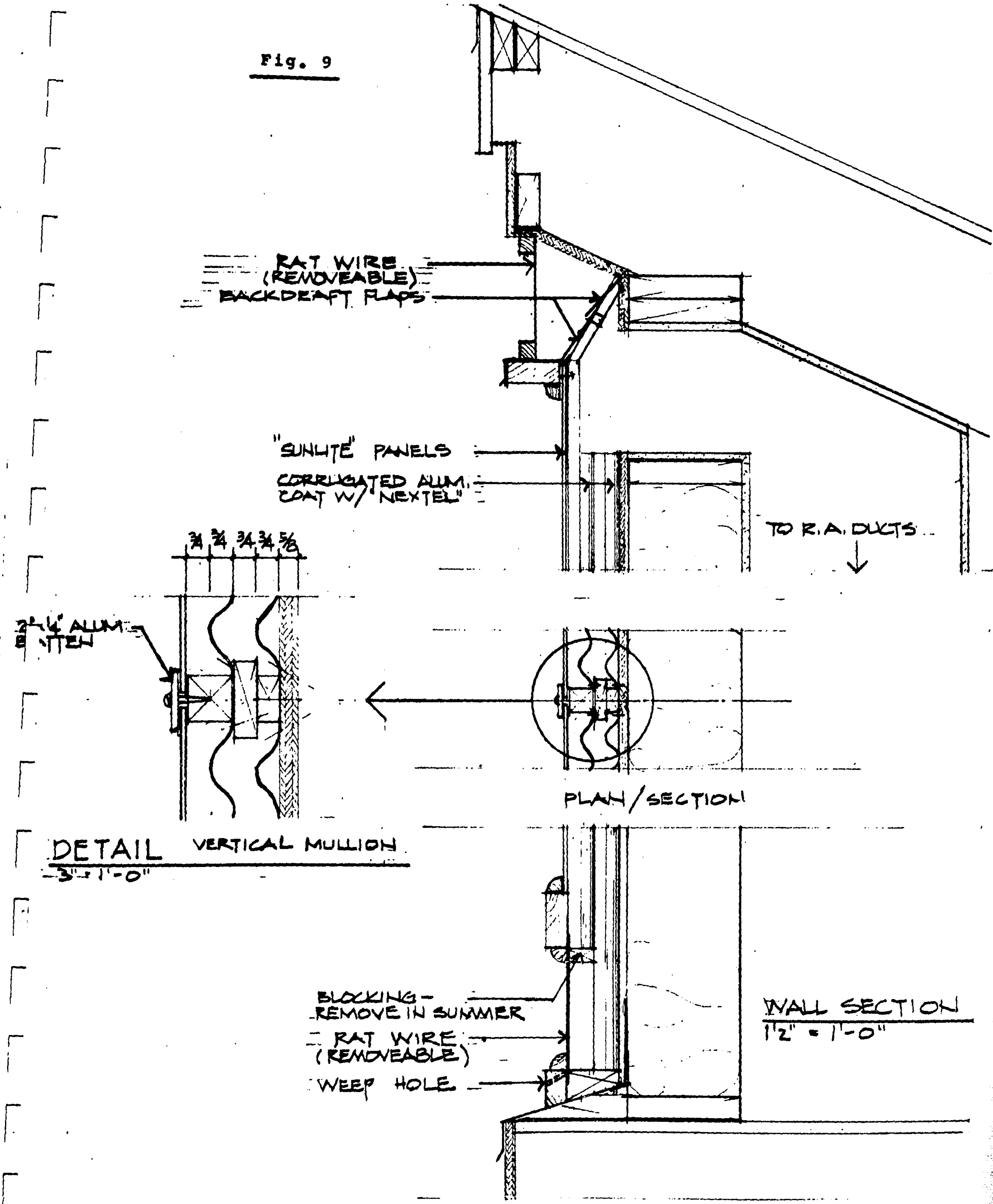

35"
COPPER ABSORBER PLATE
SELECTIVE SURFACE
93"
SINGLE
GLASS COVER
EXTRUDED ALUMINUM
HOUSING
INSULATION
REVERE
TUBE-IN-STRIP
4 1/2"
3"
3" SINGLE GLASS UNIT
1/2" IPS CONNECTION
(AT DIAGONALLY OPPOSITE ENDS)

Fig. 9


RAT WIRE (REMOVEABLE)
BACKDRAFT FLAPS
"SUNLITE" PANELS
CORRUGATED ALUM. COAT W/ "NEXTEL"
TO R.A. DUCTS
¾ ¾ ¾ ¾ ⅝
ALUM. BATTEN
PLAN / SECTION
DETAIL VERTICAL MULLION
3" = 1'-0"
BLOCKING - REMOVE IN SUMMER
RAT WIRE (REMOVEABLE)
WEEP HOLE
WALL SECTION
1½" = 1'-0"

5. SEQUENCE OF OPERATIONS

A. SYSTEM DESCRIPTION

The solar system consists of 2,500 sq. ft. (120) Revere Sun-Aid flat plate solar collector panels. These panels are single glazed with tempered 1/8" special low iron glass. The absorber plates are all copper with integral parellel tubes and are coated with a black chrome selective surface. The panels are arranged in two arrays as follows:

1. A flat mounted array consisting of 88 panels in three banks is mounted on a 30 degree sloping roof at a solar orientation of 33 degree-30' west of due south.

2. A rack mounted array consisting of 32 panels in 4 banks of 8 panels each. The panels are oriented due south at an inclination of 45 degrees.

All collectors are connected in a parallel flow, open loop, drain back configuration utilizing a separate pump for each array. Individual thermostatic monitoring of each array permits independent control of collection, thus maximizing collection efficiencies. The arrangement of panels and roof piping is shown on the system schematic and plan views.

The storage tank is a 3,600 gallon concrete vault buried below grade adjacent to the boiler room. It is covered with closed cell foam insulation and mastic. The tank is placed on a concrete pad and is surrounded by ballast rock. A french drain and sump pit is located below the concrete slab allowing surface or ground water to be pumped away from the tank. The tank interior is coated with epoxy paint to reduce leakage and fungal growth. Three heat exchangers are mounted inside the tank hanging from the inner lid. A Bilco door is located at pavement level allowing access to the heat exchangers and plumbing connections.

The mechanical equipment is located in the boiler room. The system schematic is necessary to locate a particular component in the system. All pumps and valves are numbered.

The control system and monitor is located in the mechanical room adjacent to the boiler room. All control functions are manually and/or automatically controlled from this location. The controller (Higgins Energy Associates SPM-10) is fully covered in description and operation under the controls section of this manual.

B. OPERATING MODES

1. COLLECTION

The collection is controlled by the SPM-10. Individual control is provided for each collector array. Three temperature sensors are mounted in the solar storage tank with locations at the top, middle, and bottom. One sensor is mounted on panel F-3-1 and one is mounted on panel R-1-1 (the collector numbering scheme is shown on one of the plan views). The controller compares the bottom tank sensor temperature to the rack and flat mounted collector temperatures. When the collector temperature is 20 degrees F. greater than storage, the controller closes the drain valve and turns on the collector pump for that array. Collection for that array continues until the temperature difference falls below 3 degrees F. This temperature comparison takes place once each 5 minutes, thus preventing short cycling occurences. A high limit of 190 degrees F. terminates collection in order to prevent storage overheating. Drain back occurs automatically upon power loss or below 3 degrees F. collector minus storage temperature differential.

The collection fluid is potable tap water. Collector water is pumped from the bottom of the storage tank by SPR or SPF collection pumps. The water flows to the main header and then branches to the collector subheaders. Water then flows through each collector from bottom to top. A similar subheader and header arrangement returns the solar heated water to a main return line which dumps into the top of the storage tank. Vacuum relief valves mounted at the high point of each subheader allow air to enter during drain-down.

2. MAIN LOAD LOOP

A large tank type exchanger is mounted below water level in the storage tank. A closed loop circuit connects designated loads to the load exchanger by means of motorized valves controlled by the SPM-10. Solar heated water from the exchanger is pumped by the load pump to one or more loads and is returned to the load exchanger. A flowmeter in this circuit is connected to the SPM-10 providing BTU monitoring of heat delivered to loads from the solar storage.

When a particular load calls for heat, a switch closure is sent to the SPM-10. The SPM-10 decides if the load should be heated by solar or boiler and outputs the necessary control signals. Different loads can be simultaneously heated by solar and boiler. The failsafe condition makes all loads revert to the boiler for back-up operation.

3. DOMESTIC WATER PREHEAT

All domestic hot water is preheated by flowing through a heat exchanger in the solar storage tank. This preheating is not controlled. The domestic preheat exchanger may be bypassed by manually closing valves DS-1 and DS-2 and opening valve DS-3.

A flowmeter measures the amount of water flowing through the preheat coil. The flowmeter data and heat exchanger inlet and outlet temperatures are sent to the SPM-10 which calculates the number of BTU's extracted from the solar tank and delivered to the domestic hot water supply.

4. BOILER BREACH HEAT RECOVERY

Boiler stack waste heat which is normally lost to the environment is recovered. The recovered heat is delivered to either the domestic hot water tank or is dumped into the solar storage tank.

The SPM-10 monitors the temperature in the boiler breach heat exchanger. If the temperature at sensor I6 (breach) rises 10 degrees F. above the solar storage temperature (T9) pump SP4 is turned on. The SPM-10 then decides whether to deliver the breach reclaim heat to the solar storage tank or to the domestic water heater.

MANUFACTURERS SPECIFICATIONS

DESCRIPTION OF SOLAR COLLECTORS

ACTIVE SOLAR COLLECTORS

Sun-Aid Model 332 solar collectors as manufactured by Revere Copper and Brass, Inc. have been selected. Each of the 120 modular units has overall dimensions of 93" x 35" x 4 1/2" with a net area of 20.85 square feet (gross area 22.6 square feet). The collectors are glazed with a single .125" tempered special low iron glass having a solar spectrum transmissivity of 89.5 percent. The solid copper Tube-in-Strip absorber plate has a black chrome selective surface with $\alpha = 0.95$ and $\epsilon = 0.07$. All Revere collectors have been tested in accordance with NBS "Method of Testing for Rating Solar Collectors Based on Thermal Performance", document NBSIR 74-635. Performance curves and other test data may be found in Appendix B. of this proposal.

The Revere collectors were selected based on the following rationale:

1. The 35" x 93" module utilizes the available roof area with a minimum of plumbing connections.

2. The aluminum extruded collector casing with 1/2" FPT and connections facilitates simple mounting and piping systems.

3. All copper fluid channels allow the use of standard copper piping without introducing potentials for galvanic corrosion. Further, they allow the use of water as the circulating solution resulting in better heat transfer and less maintenance. (Most glycol systems require periodic flushing, cleaning and PH testing.)

4. Revere is a major manufacturer of solar equipment. In the event of "problems" resulting from collector malfunction, they have the resources necessary to meet D.O.E. warranty requirements as stated in the Program Opportunity Notice.

5. Revere and Solar Energetics, the solar energy system consultant to the architect, have cooperated in the design and construction of previous solar projects including solar assisted heat pump systems financed by H.U.D. Cycle 3.

6. On a dollar per BTU basis, Revere Sun-Aid collectors compare favorably with other manufacturers.

DESCRIPTION OF SOLAR COLLECTORS (Continued)

ACTIVE SOLAR COLLECTORS (Continued)

A copy of the collector specification is shown following this section. Additional information concerning collector design and construction can be found in Appendix B.

PASSIVE COLLECTOR

The passive collector was fabricated using standard building materials. It is a "low technology" collector. Design was based on the low cost of materials and availability and capabilities of mechanics. As shown on the drawings, the passive collector will function to pre-warm ventilating air which it will introduce into a return air duct. Introduction of the air will be controlled by a motorized damper. Air will enter the double glass wall of the collector from the bottom and be taken off the top. At those periods during the warm months when no space heating is desired, the heated air will be returned to the outside directly from the top of the collector.

REVERE
SOLAR AND ARCHITECTURAL PRODUCTS, INC.

P.O. Box 151
Rome, New York 13440
315-338-2401

Chart for Determination of Sun-Aid Collector Model Number

Collector/Surface Option	Type of Tempered Glass: Low Iron	Type of Tempered Glass: Special Low Iron	Type of Tempered Glass: Water White
77" x 35" x 4-1/2" Single Glazed			
Black Velvet Painted Surface	111	112	113
Revere "E" Selective Surface	121	122	123
Black Chrome Selective Surface	131	132	133
77" x 35" x 4-1/2" Double Glazed			
Black Velvet Painted Surface	211	212	213
Revere "E" Selective Surface	221	222	223
Black Chrome Selective Surface	231	232	233
93" x 35" x 4-1/2" Single Glazed			
Black Velvet Painted Surface	311	312	313
Revere "E" Selective Surface	321	322	323
Black Chrome Selective Surface	331	332	333
93" x 35" x 4-1/2" Double Glazed			
Black Velvet Painted Surface	411	412	413
Revere "E" Selective Surface	421	422	423
Black Chrome Selective Surface	431	432	433

77" x 35" x 4-1/2" Collector:
Gross Area = 18.7 sq. ft.
Net Area = 17.2 sq. ft.
Single Glazed Weighs 90 lbs. dry
Double Glazed Weighs 120 lbs. dry
Holds approximately 0.3 gallons

93" x 35" x 4-1/2" Collector:
Gross Area = 22.6 sq. ft.
Net Area = 20.85 sq. ft.
Single Glazed Weighs 110 lbs. dry
Double Glazed Weighs 145 lbs. dry
HOLDS APPROX. 0.36 GALS.

Recommended minimum flow is 1/2 gpm per panel, either length.

A Subsidiary of Revere Copper and Brass Incorporated

REVERE
COPPER AND BRASS INCORPORATED

REVERE

BUILDING PRODUCTS DEPARTMENT
P.O. BOX 151
ROME, NEW YORK 13440
315-338-2401

Subject: PERFORMANCE CURVES FOR REVERE "SUN-AID" MODULAR SOLAR COLLECTORS

The attached plots demonstrate the performance characteristics of the several models of Revere "Sun-Aid" Modular Solar Energy Collectors available.

SURFACES: Revere offers three surface treatments for the copper Tube-In-Strip absorber plate. The table below lists these surface options with their respective absorptance and emittance values.

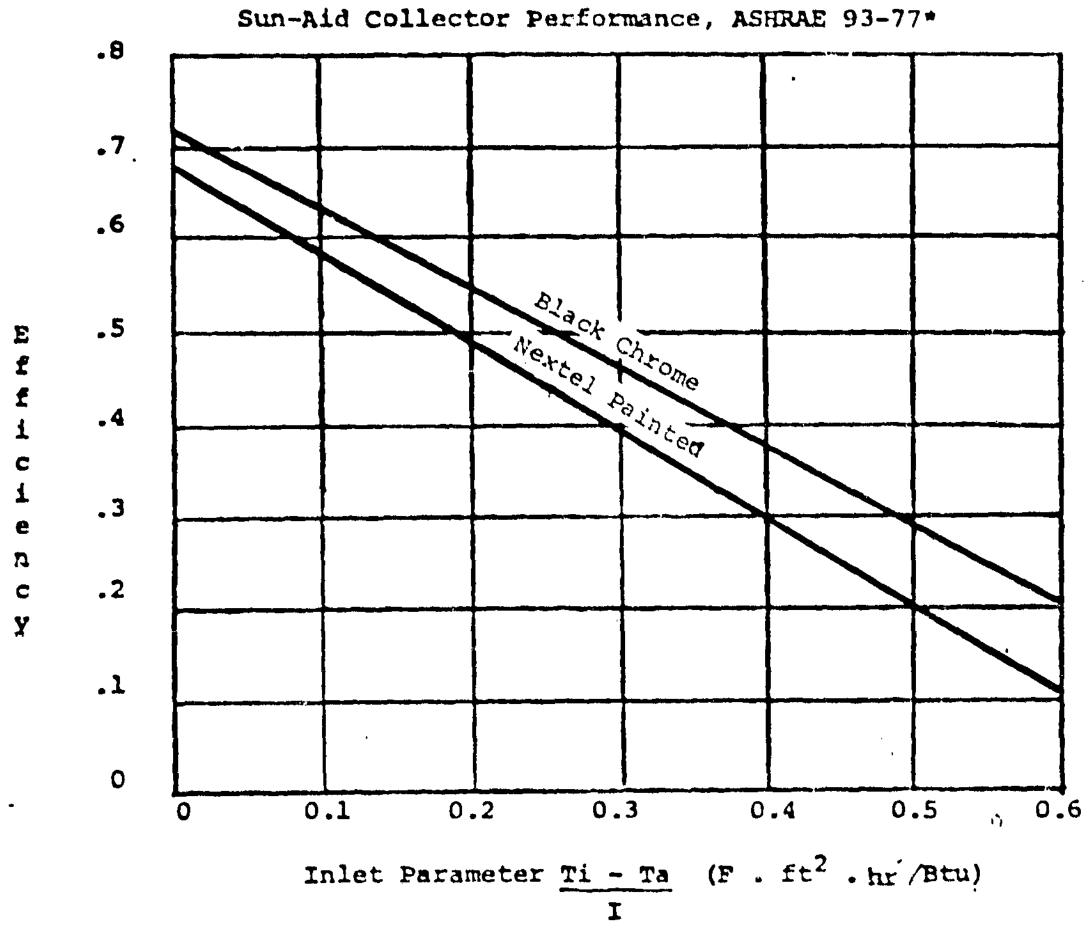
Surface Option	Solar Spectrum Absorptance	Infrared Emittance
Nextel Black Velvet Paint	0.96	0.95
Revere "E" Cuprous Oxide Selective	0.88-0.91	0.12-0.30
Black Chrome Selective	0.95	0.07

Plot number one demonstrates the difference for the various surface options. The three curves shown are for a collector with a single special low iron glazing.

GLAZINGS: Revere offers five glass cover options. All glass is 1/8" thick, tempered. The double glazed units are the sealed type with an enclosed desiccant. The table below lists the various glass options with their respective solar spectrum transmissivity.

Cover Option	Percent Solar Spectrum Transmissivity
Single Special Low Iron	89.5%
Single Water White Crystal	91.5%
Double Low Iron	73.1%
Double Special Low Iron	80.1%
Double Water White Crystal	83.7%

PLOT #1 Comparison of Black Chrome and Nextel Painted Surfaces on Collectors with a Single Glass Cover



Black Chrome Selective Surface and Single Special Low Iron Glass

$$\text{Efficiency} = .718 - .849 \frac{Ti - Ta}{I}$$

Nextel Painted Surface and Single Special Low Iron Glass

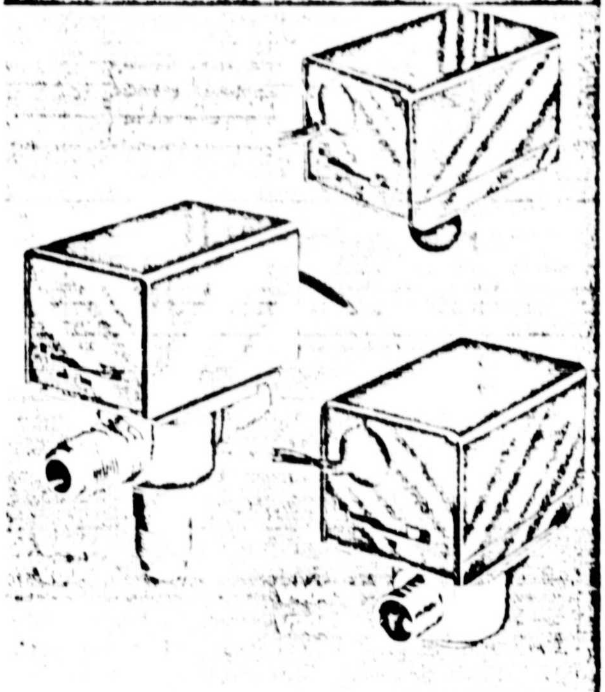
$$\text{Efficiency} = .679 - .949 \frac{Ti - Ta}{I}$$

*NOTE: - The ASHRAE 93-77 procedures differ from the NBSIR 74-635 procedures making a direct comparison of ratings obtained from the two methods difficult without the actual test data.

Honeywell

MOTORIZED VALVES

THESE VALVES CONSIST OF AN ACTUATOR MOTOR AND VALVE ASSEMBLY FOR CONTROLLING THE FLOW OF STEAM, HOT OR COLD WATER.



- The V4043 and V8043 provide 2-position, straight-through control of supply water.
- The V4044 and V8044 provide 2-position diverting control of supply water.
- Compact construction for easy installation.
- Manual opener for valve operation on power failure. Valve returns to automatic position when power is restored.
- Choice of sweat copper end connections or flare fitting end connections.
- Motor actuator may be replaced without removing the valve body or draining the system.
- Complete powerhead may be removed without breaking the line connections.
- Sweat fit models may be installed without disassembling the valve.
- Fits under the cover of most baseboards.
- Available with integral auxiliary end switch (V8043E,F; V8044E) to permit sequencing of auxiliary equipment.
- V4043E,G,J provide straight-through control of steam.
- V4043L,M with Class F sealed motor has higher maximum fluid temperature ratings.

V4043A-C,E,G,J-M; V4044A-C,G; V8043A,B,E,F; V8044A-E

M.S.
REV. 5-77 (.086)

Form Number 60-2133-2

SPECIFICATIONS

TRADELINE MODELS

Tradeline models are selected and packaged to provide ease of stocking, ease of handling, and maximum replacement value. Tradeline model specifications are the same as those of standard models except as noted below.

TRADELINE MODELS AVAILABLE: V8043F (see Table I).

CAPACITY RATING: 3.5 Cv [3.0 kv] nominal. (See Temperature and Flow Ratings table under Standard Models.)

REPLACEMENT POWERHEAD: Part No. 130441UA.

ADDITIONAL FEATURES:
End switch enclosure included.
Tradeline pack with cross reference label and special instruction sheet.

STANDARD MODELS

MODELS: V4043, V4044, V8043, V8044 Motorized Valves. See Table I.
TEMPERATURE AND FLOW RATINGS:

VALVE FAMILY	CAPACITY RATING		MAX. CLOSEOFF PRESSURE[a]		MAX. FLUID TEMP		MAX. AMBIENT TEMP	
	Cv	kV	PSI	kPa	F	C	F	C
V8043	3.5	3.0	20	138	240	115.5	125	51.5
	8.0	7.0	8	55	240	115.5	125	51.5
V4043A,C,K,L,M	1.0	.9	50	345	200	93.5	125	51.5
	2.5	2.0	30	207	200	95.5	125	51.5
	3.5	3.0	20	138	200[b]	95.5	125	51.5
	8.0	7.0	8	55	200	95.5	125	51.5
V8044	4.0	3.5	10	69	240	115.5	125	51.5
	7.0	6.0	10	69	240	115.5	125	51.5
V4044	4.0	3.5	10	69	200	95.5	125	51.5
	7.0	6.0	10	69	200	95.5	125	51.5
V4043E,G,J steam	–	–	15	103	250	121.0	125	51.5

[a]Static Pressure Rating: 125 psi [862 kPa], all models.
[b]240 F [115.5 C] for V4043L,M using Class F sealed motor.

DETERMINATION OF WATER FLOW CHARACTERISTICS

The pressure drop in psi [kPa], equivalent feet [metres] of pipe, or feet of water [kPa] may be calculated from Figs. 1-6 using the following procedure.

1. Calculate the flow rate needed to heat the zone.
2. Determine the Cv [kv] rating of the motorized valve.
3. Select the graph corresponding to the Cv [kv] rating.
4. Determine the pressure drop using one of the following procedures.

PRESSURE DROP IN PSI [kPa]

1. Locate the flow rate at the bottom of the graph on page 3.
2. Draw a line upward from the flow rate to the intersection of the curve.
3. Draw a line from the intersection to the left-hand edge of the graph to determine pressure drop in psi [kPa].

(continued on page 3)

ORDERING INFORMATION

WHEN PURCHASING REPLACEMENT AND MODERNIZATION PRODUCTS FROM YOUR TRADELINE WHOLESALER OR YOUR DISTRIBUTOR, REFER TO THE TRADELINE CATALOG OR PRICE SHEETS FOR COMPLETE ORDERING NUMBER, OR SPECIFY–

1. Order number.
2. Voltage and frequency.
3. Size and type of end connections.
4. Cv rating.
5. Lead length if different from standard.
6. Replacement parts, if needed.

IF YOU HAVE ADDITIONAL QUESTIONS, NEED FURTHER INFORMATION, OR WOULD LIKE TO COMMENT ON OUR PRODUCTS OR SERVICES, PLEASE WRITE OR PHONE:

1. YOUR LOCAL HONEYWELL RESIDENTIAL DIVISION SALES OFFICE (CHECK WHITE PAGES OF PHONE DIRECTORY).
2. RESIDENTIAL DIVISION CUSTOMER SERVICE
HONEYWELL INC., 1885 DOUGLAS DRIVE NORTH
MINNEAPOLIS, MINNESOTA 55422 (612) 542-7500

(IN CANADA–HONEYWELL CONTROLS LIMITED, 740 ELLESMERE ROAD, SCARBOROUGH, ONTARIO M1P 2V9)
INTERNATIONAL SALES AND SERVICE OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD.

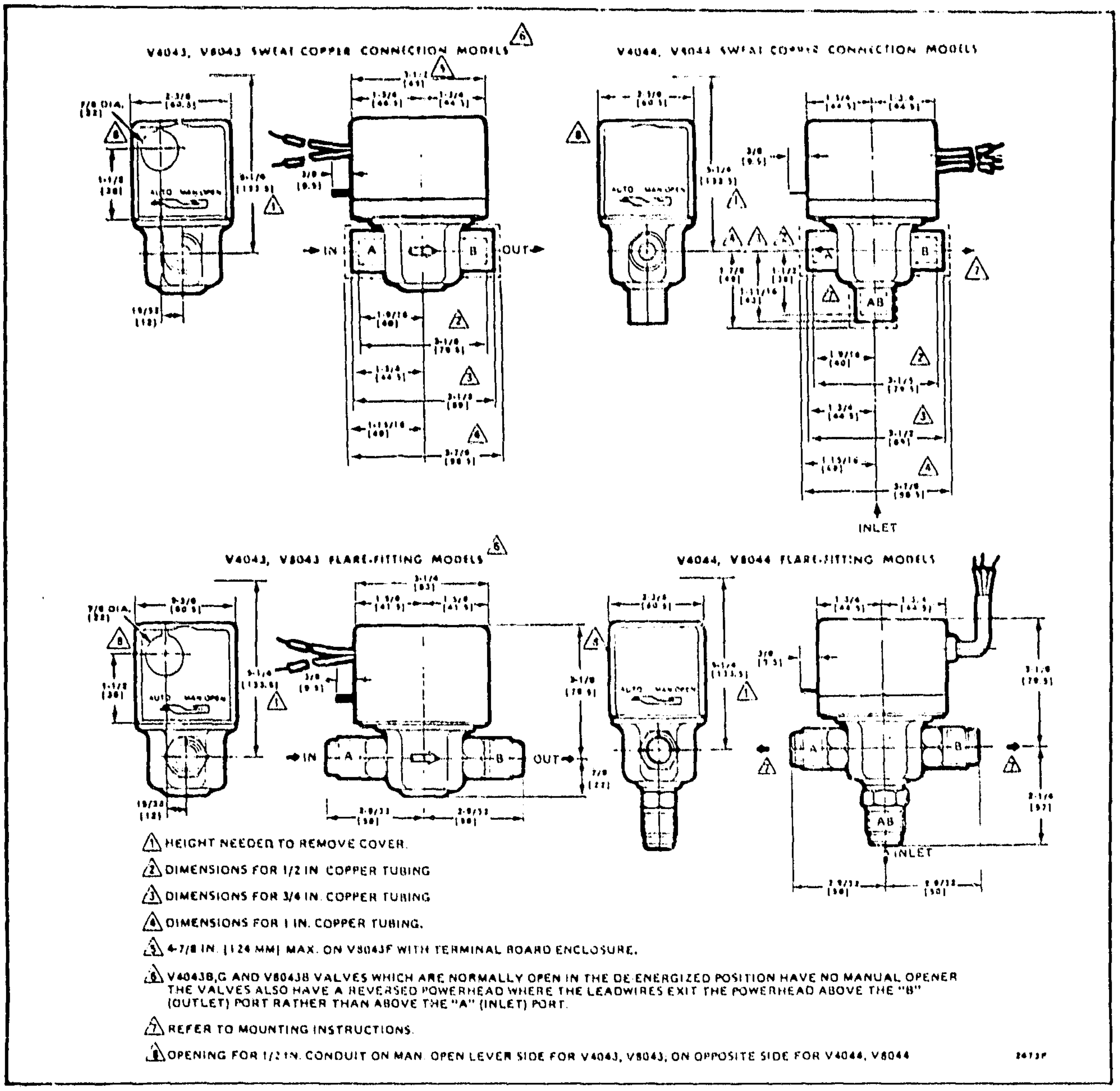


FIG. 7—INSTALLATION DIMENSIONS IN INCHES [MILLIMETRES IN BRACKETS].

ELECTRICAL RATINGS (see Table 1 for voltage of specific models):

VOLTAGE	AMP
24	0.320
100	0.087
120	0.080
208	0.044

VOLTAGE	AMP
220	0.042
240	0.040
277	0.037

CHANGEOVER AQUASTAT: 120V, 3.0 amp with 10.0 amp inrush.

END SWITCH: 120V, 4.4 amp running with 26.4 amp inrush. Pilot duty 50 VA at 24V.

TIMING: V4043 and V8043 open or close in 15 seconds. V4044 and V8044 divert flow in 30 seconds.

DIMENSIONS: See Fig. 7.

O RING REPLACEMENT: Part No. 802344.

MANUAL OPENER: Manual opener (on all except the straight-through, normally open valves) opens the valve in case of power failure. Valve returns to automatic position when power is restored.

CAPACITY RATING (see Table 1): identifying grooves on inlet port indicate the Cv [kv] rating of the valve:
- 1 groove–3.5 Cv [3.0 kv].
- 2 grooves–4.0 Cv [3.4 kv].
- 3 grooves–1.0 Cv [86 kv].
- 4 grooves–7.0 or 8.0 Cv [6.0 or 6.9 kv] depending on model.
- 1 narrow groove and 1 wide groove–2.5 Cv [2.1 kv].

UNDERWRITERS LABORATORIES INC. LISTED:

V4043A,B,E,G,J-M V4044A,B,E V8044E	File No. MH1639, Guide No. YIOZ

COMPONENT RECOGNIZED:

V4043C,F V4044C	File No. MH1639, Guide No. YIOZ2

POWERHEAD REPLACEMENT (see Table II): Includes motor, housing, rubber plug, O ring, 4 mounting screws, and 1 sheetmetal screw.

INSTALLATION

CAUTION

1. Installer must be a trained, experienced serviceman.
2. Disconnect power supply before connecting wiring to prevent electrical shock and equipment damage.
3. Normally it is not necessary to remove the powerhead from the valve body during installation. If the valve must be disassembled, be certain that it is reassembled with the water flow in the direction of the arrow. Reversal of the powerhead will result in damage to the gear train.
4. Always conduct a thorough checkout when installation is complete.

MOUNTING

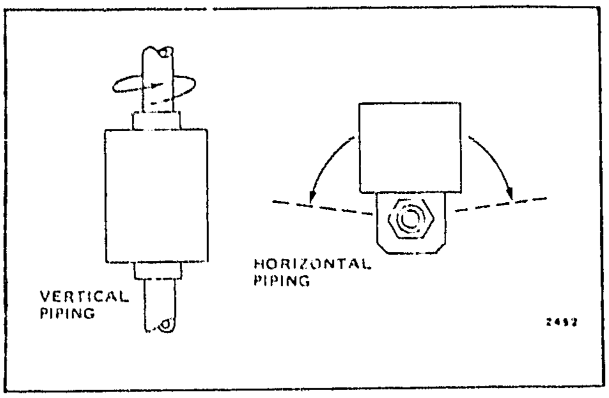


FIG. 8–MOUNTING POSITIONS.

The valve may be mounted in any position on a vertical line. If valve is mounted horizontally, the powerhead must be even with or above the center line of the piping. Make sure that enough room is provided above the powerhead to remove the cover for servicing.

Mount the valve directly in the tube or pipe. Make sure that flow through the valve is in the direction indicated by the arrow stamped on the valve body.

On diverting valves, the 3 fittings or ports are labeled on the bottom of the valve body casting. In many applications, port A is connected to the coil unit and is closed when the valve is de-energized. Port B is connected to the coil bypass and is open when the valve is de-energized. Port AB is the inlet and is open at all times. See Fig. 7. In other applications, port B is connected to the coil and is open when the valve is de-energized. Port A is connected to the coil bypass. Refer to equipment manufacturer's instructions for proper fitting of diverting valves.

FLARE FITTING MODELS

Use new, properly reamed pipe, free from chips. The valve body is threaded for standard 5/8 in. OD copper, 45 degrees SAE flare fitting nuts. These nuts are not furnished with the valve and must be obtained separately.

SWEAT COPPER MODELS

1. Use new, properly reamed pipe, free from dents or corrosion.
2. Place valve onto the pipe. Set the manual opener lever to MAN. OPEN before applying heat. This will protect the plug inside the valve by removing it from the heat.
3. Sweat joints keeping the outer surface free from solder. DO NOT use silver solder because of the high melting temperatures required.

TO INSTALL REPLACEMENT POWERHEAD

IMPORTANT

Installation of new powerhead does not require the removal of the valve body from the pipe line. It is, however, necessary to drain the water from the system before beginning the installation.

1. Disconnect the valve from the electrical power source and remove the conduit connections if fitted.
2. Place the manual opening lever on the old powerhead in the MAN. OPEN position.
3. With the cover off, remove the 4 screws securing the powerhead to the valve body. Remove the old O ring from the valve body.
4. Place the new O ring in the circular slot on the top of the valve body.
5. Install the new powerhead –
   - Place the manual opening lever on the new powerhead in the MAN. OPEN position.
   - On newer models, align the powerhead by fitting the hex head screw on bottom of powerhead into the hole on top of valve body.
   - For use with older valve bodies, note the position of the old powerhead and install the new one in the same position. Remove hex screw, push metal positioning pin on the new powerhead flush with the bottom plate before beginning installation. Align the powerhead so the manual opening lever is at the inlet end of the valve body. The inlet port will be closed with the valve in the de-energized position.
6. Reconnect electrical connections.

Inspect the powerhead installation and the valve body to insure that all connections and adjustments have been correctly made. Adjust the thermostat or controller connected to the valve so the valve runs through its cycle. Make sure the valve runs smoothly and positively from closed to open to closed again.

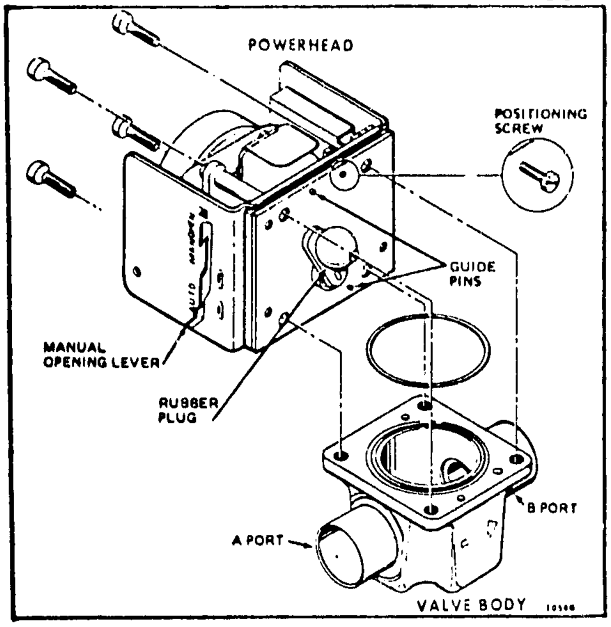


FIG. 9–POWERHEAD MUST BE ALIGNED SO THAT THE GUIDE PINS AND THE POSITIONING PIN IN THE POWERHEAD FIT THE HOLES IN THE VALVE BODY.

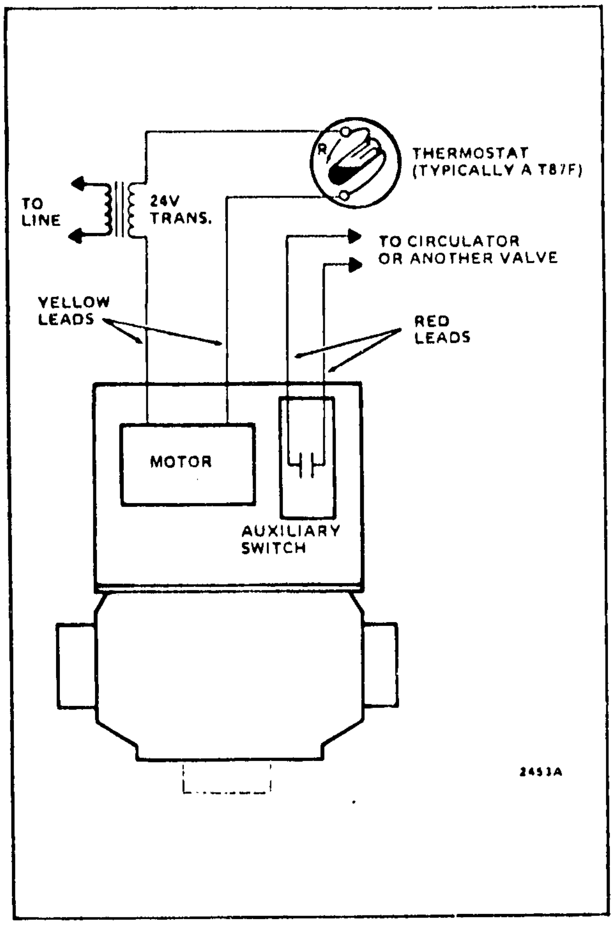


FIG. 10–TYPICAL WIRING FOR V8043E, V8044E.

WIRING

All wiring must agree with local codes and ordinances. Connections to the individual valves are shown in Figs. 10-11. See Figs. 12-18 for typical hookups.

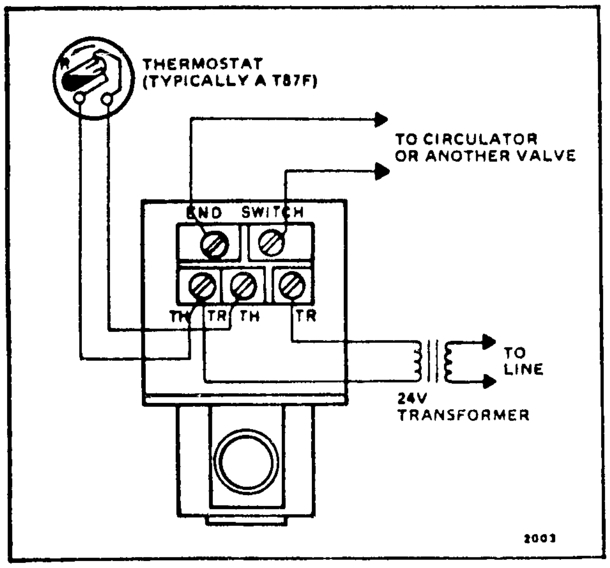


FIG. 11–TYPICAL WIRING FOR V8043F.

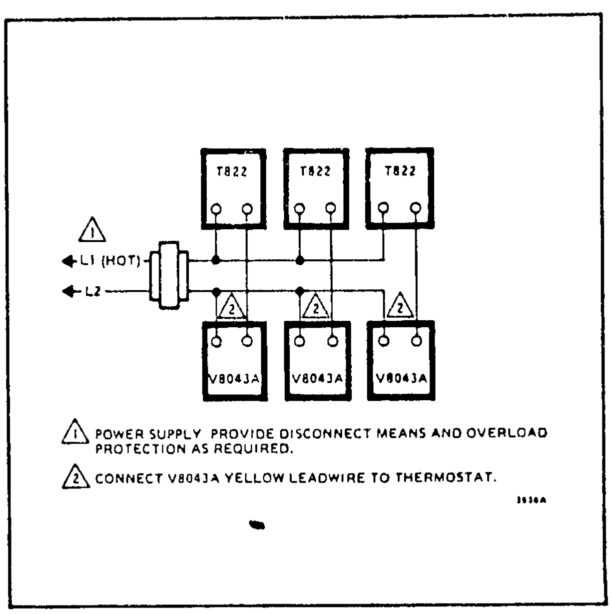
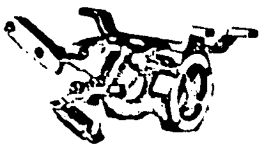


FIG. 12–T822 THERMOSTAT, V8043A VALVE HOOKUP.

motors and valves

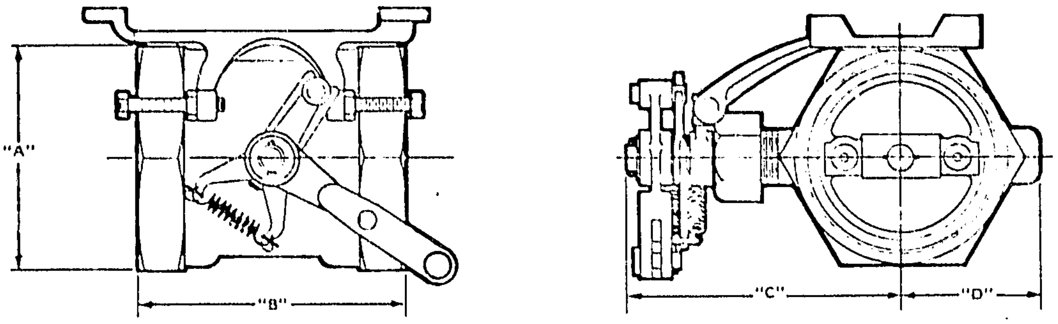
V51B BUTTERFLY VALVE



REGULATES FLOW OF WATER OR STEAM ON APPLICATIONS WHERE TIGHT CLOSE-OFF IS NOT REQUIRED.

For tight close-off, a final shutoff valve must also be used. Typical applications include zone control of gravity hot water or low pressure steam heating systems. V51B valves are suitable for use with Modutrol motors and Q100 Linkage. With strain release and stop bracket. Body Pattern: Straight-through, screwed. Body Material: Brass. Maximum Operating Temperature: 250 F [121 C]. Maximum Operating Pressure: 20 psi [138 kPa].

ORDER NUMBER	VALVE SIZE (NPT)	REMARKS
V51B1007	1-1/2 inch	
V51B1023	2 inch	
V51B1221	2-1/2 inch	With metaseal coating and Teflon packing.
V51B1239	3 inch	
V51B1247	4 inch	



VALVE SIZE	DIMENSIONS							
	A		B		C		D	
	IN.	mm	IN.	mm	IN.	mm	IN.	mm
1-1/2	2-11/16	68.3	3- 1/16	77 8	4-7/8	123 8	1-5/8	41.3
2	3- 3/16	81.0	3- 9/16	90 5	4-7/8	123 8	1-7/8	47 6
2-1/2	3- 5/8	92 0	4-11/16	119 1	4-7/8	123 8	2 5/16	58 7
3	4- 1/16	103 2	4- 1/4	108 0	5-3/16	131 8	2 5 9	66 7
4	5- 5/16	134 9	5- 5/16	134 9	5-5/16	134 9	3-1/4	82 6

2679C

Dimensions in inches [millimetres] of V51B.

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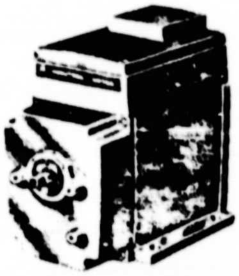
motors and valves

M845A,B,C,E MODUTROL MOTORS



M845 with Cover Mounted Transformer

TWO-POSITION, SPRING-RETURN MOTORS.

Used to operate dampers or valves where desirable to return controlled element to starting position on power failure or interruption. Enclosed spring-return mechanism field removable for access to auxiliary switches. 24V, 50/60 Hz. Timing: 60 seconds. Stroke: 160 degrees. Maximum Operating Torque: 50 lb.-in. [5.7 N·m]. Crankshaft: Double-ended, 3/8 in. [9.5 mm] square, untapped. Approximate Dimensions: 7-1/2 in. [190.5 mm] high without cover-mounted transformer, 8-5/16 in. [211 mm] high with transformer; 5-5/8 in. [142.9 mm] wide; 9-1/4 in. [235 mm] deep. Listed by Underwriters Laboratories Inc.–M845A,B,E; CSA certified.

AUXILIARY SWITCH RATINGS (amperes)[a]:

	120V ac	240V ac
Full Load	7.2	3.6
Locked Rotor	43.2	21.6

[a]Switch rating is for 1 contact only; if both are used, second contact is rated 40 VA.

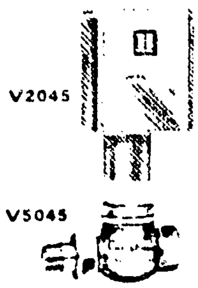
ACCESSORIES:
See PARTS and ACCESSORIES, pages 283-296.

TRADELINE model.

ORDER NUMBER	POWER CONSUMPTION		MOTOR ACTION ON POWER LOSS	AMBIENT TEMPERATURE RANGE		INCLUDES
	WATT	VA		F	C	
M845A1001	24	30	Closes	15 to 125	- 9 to + 52	1 spdt auxiliary switch
M845A1027	24	30	Closes	15 to 125	- 9 to +52	120/208/240V multitap transformer; 1 spdt auxiliary switch
M845B1000	54[a]	60	Closes	-40 to +125	-40 to +52	Internal heater; 1 spdt auxiliary switch
M845B1018	54[a]	60	Closes	-40 to +125	-40 to +52	Internal heater; 120V cover transformer; 1 spdt auxiliary switch
M845C1009	24	30	Closes	15 to 125	- 9 to +52	
M845E1007	24	30	Opens	15 to 125	- 9 to +52	120V cover transformer, 1 spdt auxiliary switch

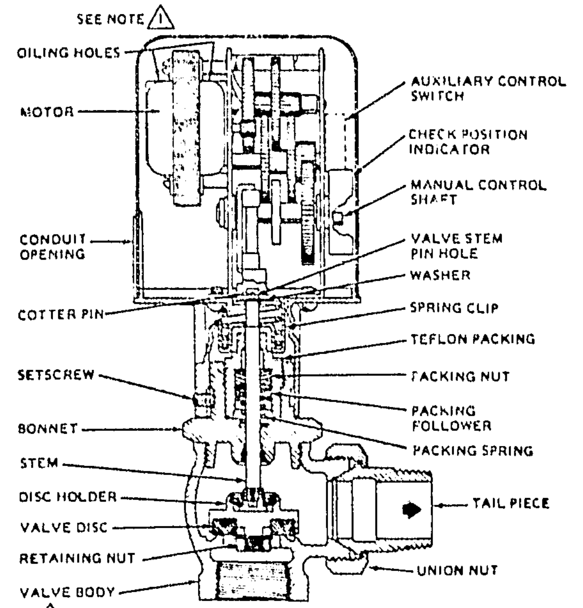
[a]Includes 30 watts for internal heater

V5045A VALVE BODY



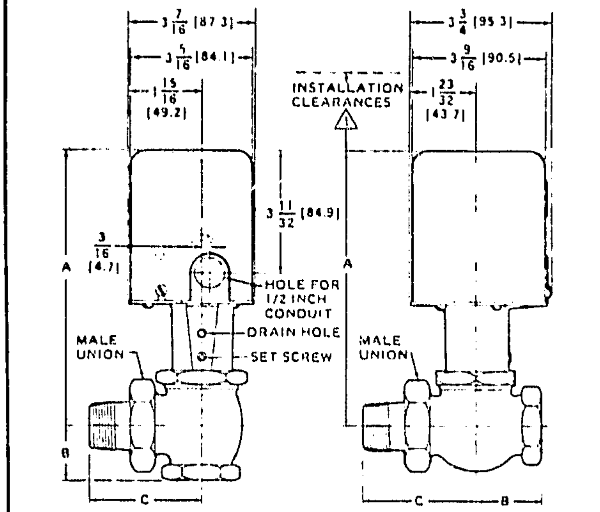
SINGLE-SEATED VALVE FOR 2-POSITION CONTROL OF HOT OR CHILLED WATER OR STEAM RADIATORS, AND FOR RESIDENTIAL ZONE CONTROL.

Requires a V2045A operator. Body Material: Brass. Pipe Connections: Female inlet, male union outlet. Disc: Composition, replaceable. Fluid Temperature: 250 F [121 C] maximum. Steam Pressure: 15 psi [103.4 kPa] maximum. Seat: Integral, brass. Packing: Molded Teflon cones, spring-loaded, self-adjusting.



1 TO FREE ROTOR, LIGHTLY TAP MOTOR LAMINATIONS WITH SCREWDRIVER AT POINT INDICATED BY ARROW.

Cross Section of V2045A-V5045A.



VALVE SIZE	ANGLE TYPE					
	A		B		C	
	IN	mm	IN	mm	IN	mm
1/2 IN	7-3/8	187.3	1-1/8	28.6	2-13/16	71.4
3/4 IN	7-3/8	187.3	1-1/16	27.0	3-1/8	79.4
1 IN	7-1/2	190.5	1-1/2	38.1	3-1/8	79.4
1-1/4 IN	7-11/16	195.3	1-3/4	44.5	3-9/16	90.5
1-1/2 IN	7-7/8	200.0	2	50.8	3-3/4	95.3
2 IN	8-1/8	206.4	2-1/4	57.2	3-5/16	84.1

VALVE SIZE	STRAIGHT-THROUGH TYPE					
	A		B		C	
	IN.	mm	IN.	mm	IN.	mm
1/2 IN.	7-3/4	196.9	1-3/4	44.5	3-[illegible]/16	77.8
3/4 IN.	7-13/16	198.4	2-1/16	52.4	3-1/16	77.8
1 IN.	7-15/16	201.6	1-13/16	46.0	3-1/8	79.4
1-1/4 IN	8-5/16	211.1	2-3/16	55.6	3-3/8	85.7
1-1/2 IN	8-5/8	219.1	2-1/4	57.2	3-15/16	100.0
2 IN.	9-1/8	231.8	2-9/16	65.1	3-15/16	100.0

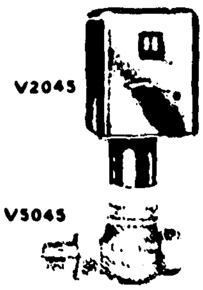
1 ADD TO DIM. A. 4 IN. [101.6 mm] FOR REMOVAL OF COVER, 2 IN. [50.8 mm] IF VALVE BODY INSTALLED FIRST, THEN ACTUATOR.

V5045A Dimensions.

ORDER NUMBER	APPLICATION	VALVE PATTERN	SIZE (NPT)	FLOW CAPACITY		CLOSE-OFF RATING FOR WATER[a]	
				Cv	kv	psi	kPa
V5045A1122	Control 2-pipe steam radiators.	Straight-through	1/2	3.8	3.3	100	689.5
V5045A1130			3/4	5.4	4.6	85	586.0
V5045A1148			1	10.8	9.3	45	310.3
V5045A1155			1-1/4	16.0	13.7	25	172.4
V5045A1163			1-1/2	25.0	21.4	18	124.1
V5045A1171			2	40.0	34.3	12	82.7
V5045A1189	Control 2-pipe steam radiators and 1-pipe steam radiators.	Angle	1/2	3.8	3.3	100	689.5
V5045A1197			3/4	5.4	4.6	85	586.0
V5045A1205			1	10.8	9.3	45	310.3
V5045A1213			1-1/4	16.0	13.7	25	172.4
V5045A1221			1-1/2	25.0	21.4	18	124.1
V5045A1239			2	40.0	34.3	12	82.7

[a]Using V2045A powerhead.

V2045A MOTORIZED VALVE POWERHEAD



TWO-POSITION ACTUATOR FOR V5045A VALVE BODY.

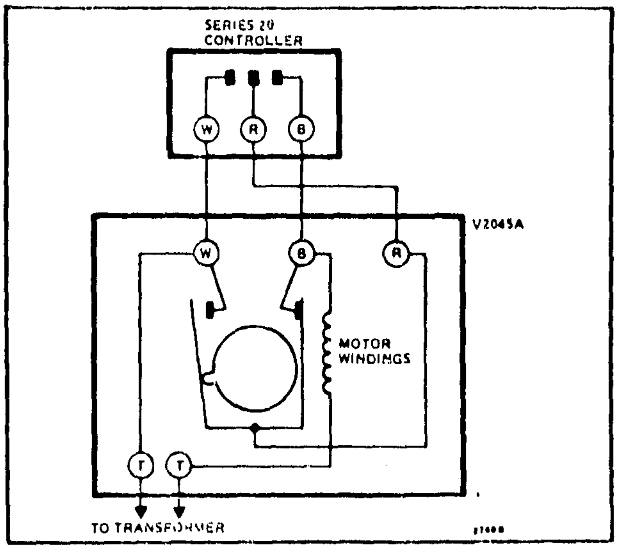
With position indicator. May be manually opened during power-off periods and will automatically return to the command of controller when power is restored. Mounts directly to bonnet of V5045A Valve Body. Power Consumption: 12 watt nominal at 60 Hz. VA Rating: 21 VA nominal at 60 Hz. Ambient Temp: 32 F [0 C] minimum, 125 F [52 C] maximum.

ACCESSORIES:

114191B Auxiliary Switch Assembly, field addable to V2045A to control an additional valve from a single thermostat. 10 amp for 120 to 240V ac; with three 30 in. [762 mm] leads.

126149B Adapter Kit for using V2045A Valve Actuator with V5011 Valve.

311057 Special Lubricant for repacking V2045A (2 ounce tube enough for 25 packings).



V2045A schematic.

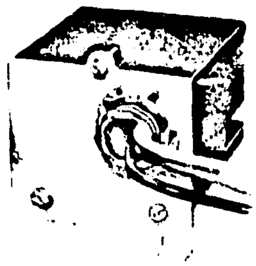
TRADELINE model.

ORDER NUMBER	CONTROL CIRCUIT	REQUIRED THERMOSTAT
V2045A1038[a]	Spdt 3-wire, 24V	Low voltage spdt thermostat; such as T87F1859,T222,T282

[a]Order AT72 Transformer separately.

relays and contactors

R8225A,B,C,D FAN RELAY



FOR 24 VOLT CIRCUIT CONTROL OF LINE VOLTAGE FAN MOTORS AND AUXILIARY CIRCUITS.

Used in heating, cooling or heating-cooling systems. Integral 1/2 inch conduit spud allows relay to be mounted on standard junction box. Contacts: Silver cadmium oxide. Maximum Operating Ambient Temperature: 115 F [46 C]. Mounting Means: Threaded 1/2 inch NPT conduit spud. Approximate Dimensions: 2-11/16 in. [68.3 mm] high, 2-1/2 in. [63.5 mm] wide, 3-7/16 in. [87.3 mm] deep. Listed by Underwriters Laboratories Inc.; CSA certified.

TRADELINE model.

ORDER NUMBER	SWITCHING	CONFIGURATION AND COLOR CODING
R8225A1017[a] R8225A1041[b]	Spdt, one N.O., one N.C.	BLACK, RED (N.O.); BROWN (N.C.)
R8225B1007	Spst, N.O.	BLACK — BLACK
R8225C1005	1 spst N.O. 1 spst N.C.	BLACK — BLACK RED — RED
R8225D1003	Dpst 1 main N.O. 1 aux. N.O.	LOAD CONTACTS: BLACK — BLACK AUXILIARY CONTACTS: YELLOW — YELLOW

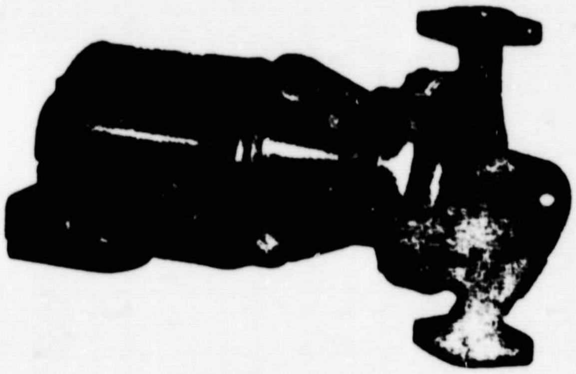
[a]Includes 134259 Flush Mounting Bracket.
[b]With fine silver contacts, special mounted.

ELECTRICAL RATINGS:
Coil Voltage—24V, 60 Hz.
Maximum Inrush—11 VA.
Maximum Sealed—6 VA.
Pull-in Voltage—18V at 75 percent rated voltage.

CONTACT RATINGS (amperes):

	120V ac			240V ac		
	N.O.[a]	N.C.	AUXILIARY	N.O.	N.C.	AUXILIARY
Full Load	13.8	13.8	3.0	8.0	6.9	1.9
Locked Rotor	82.8	82.8	18.0	48.0	41.4	11.4
Resistive	16.0	14.0	3.0	8.0	7.0	2.0
Horsepower	3/4 hp	3/4 hp	1/10 hp	1 hp	3/4 hp	1/8 hp

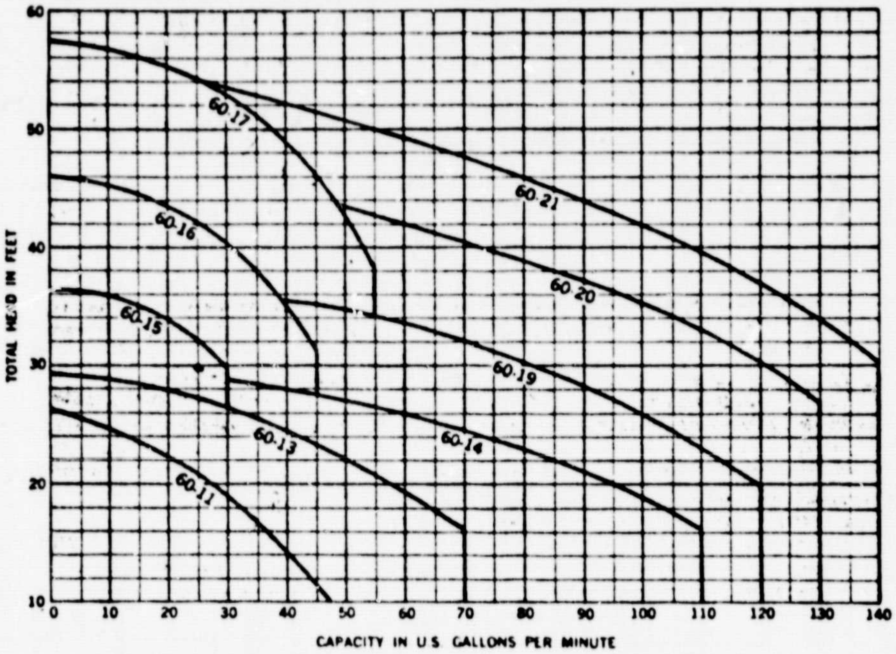
[a]TRADELINE models rated 16 amp Full Load, 96 amp Locked Rotor, at 1 hp.



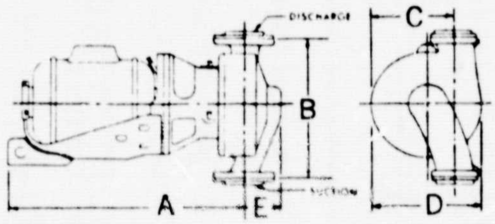
B&G Series 60 Centrifugal Pumps

Bronze fitted construction – equipped with 1750 RPM, 60 cycle, drip-proof motors and companion flanges. 60-11S, 13S, 13T, 14S, 14T also available in all bronze construction. Add "B" to unit number when ordering. Built-to-order units are available when conditions cannot be met by stock pump selections.

Selection Chart



Add "S" to pump number when ordering single phase pumps.
Add "T" to pump number when ordering three phase pumps.



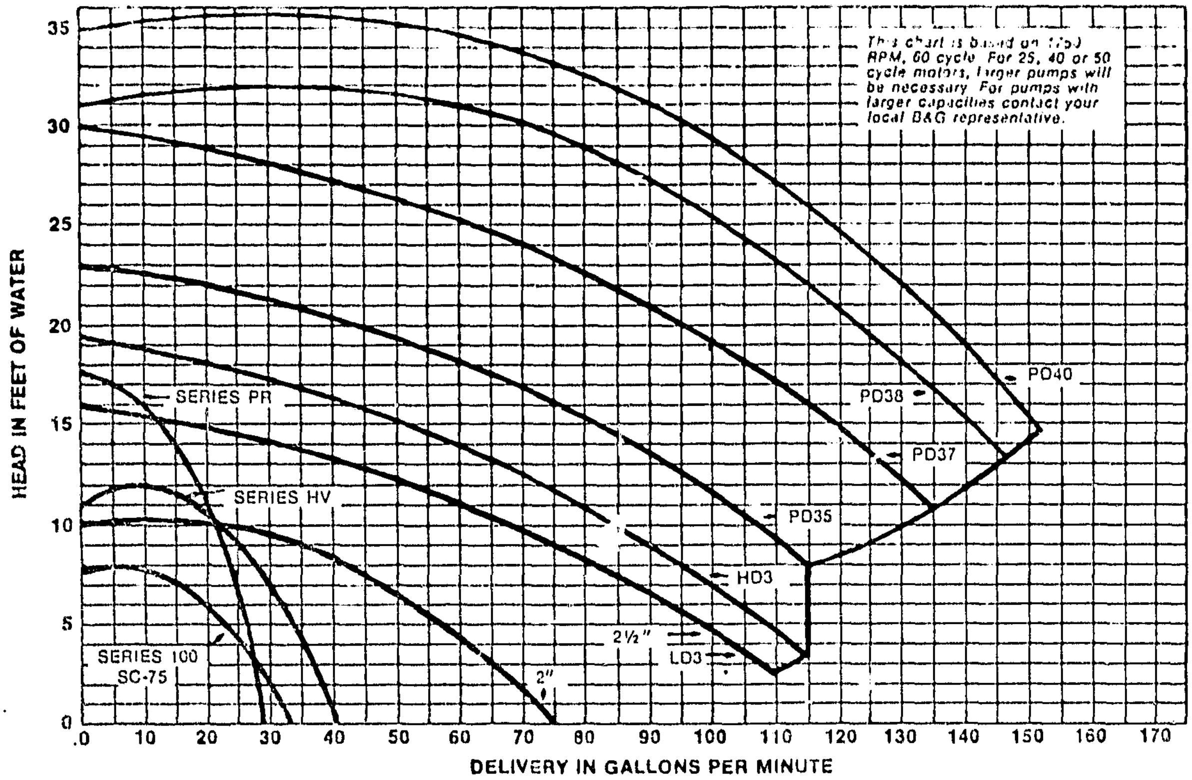
STANDARD VOLTAGES
¼ HP, 1 PH, 115 Volts.
⅓ to 1½ HP, 1 PH, 115/230 Volts.
¼ to ¾ HP, 3 PH, 208-230/460 Volts.
1 to 2 HP, 208 or 230/460 Volts.
All single phase motors have built-in overload protection.

Dimensions

UNIT NO.	PUMP SIZE	MOTOR H.P.	APPROXIMATE DIMENSIONS IN INCHES NOT TO BE USED FOR INSTALLATION				
			A	B	C	D	E
60-11	1¼AA	¼	15¾	11	5	7½	3 7/16
60-13	1½AA	½	17½	11½	5⅛	7⅞	3⅝
60-14	2AA	¾	18⅛	11½	5⅛	8	3¾
60-15	1½A	½	21¼	13½	5⅝	9½	3¼
60-16	1½A	¾	21¾	13½	5⅝	9½	3¼
60-17	1½A	1	19¾	13½	5⅝	9½	3¼
60-19	2A	1	19¾	14	5¾	9⅞	3½
60-20	2A	1½	20⅝	14	5¾	9⅞	3½
60-21	2A	2	21⅞	14	5¾	9⅞	3½

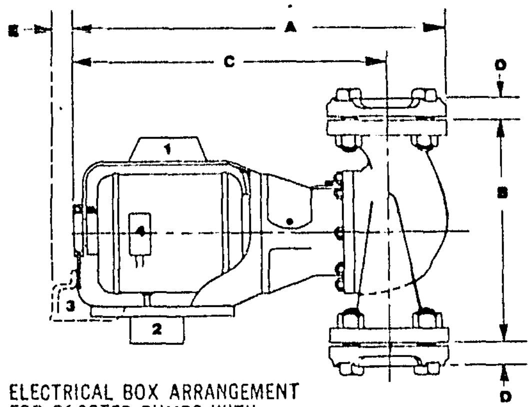
IRON AND BRONZE BOOSTER PUMP

*Performance characteristics are based on using 1¼" or 1½" flanges. When using ¾" or 1" flanges performance will be slightly reduced.



DIMENSIONS & WEIGHTS

MODEL NO.	FLANGE SIZE NPT INCHES (specify size)	DIMENSIONS IN INCHES (open drip-proof) A	B	C	D	E	APPROX. SHPG. WT. LBS. IRON BODY	BRONZE
SERIES 100	¾	15	6⅜	12⅞	9/16	—	21	21
	1 & 1¼				¾	—		
	1½				15/16	—		
SC-75	SWEAT		7⅜		—	—	—	20
SERIES PR	¾	16¼	8½	13⅝	9/16	—	35	37
	1 & 1¼				¾	—		
	1½				15/16	—		
SERIES HV	1	16⅛		13¼	⅝	—	28	30
	1¼ & 1½				¾	—		
2	2	17⅜		14¼	13/16	—	40	42
2½	2½		10	14⅛	1 1/16	—	58	62
LD3	3					—	55	60
HD3		18⅜		15⅛		—	60	65
PD35-S		20¾	12	17⅜		1⅛	78	83
PD35-T		20¼		16⅞			75	80
PD37-S		21¼		17⅞			85	90
PD37-T		20¾		17⅜			82	87
PD38-S		24	14½	19½	1¼	—	128	138
PD38-T		'4¼		19¾		—	125	135
PD40-S		24⅝		20⅛		—	130	140
PD40-T		25⅛		20⅝		—	127	137



ELECTRICAL BOX ARRANGEMENT FOR BOOSTER PUMPS WITH BELL & GOSSETT MANUFACTURED MOTORS

Model Number	#1	#2	#3	#4
Series 100 and SC-75	All Standard	Other 1Ø	3Ø	—
Series HV and 2"	115 Volt 1Ø Only			
Series PR 2½", LD3 and HD3	—	1Ø		
PD35 and PD37		—	All	
PD38 and PD40			—	All

TYPICAL SPECIFICATION

The Contractor shall furnish and install In-The-Line Pumps as illustrated on the plans and in accordance with the following specifications:

1. The pumps shall be of the horizontal, oil-lubricated type, specifically designed and guaranteed for quiet operation. Suitable for 125# working pressure.

2. The pumps shall have a ground and polished steel shaft with integral thrust collar. The shaft shall be supported by two horizontal sleeve bearings designed to circulate oil. The pumps are to be equipped with a water-tight seal to prevent leakage. Mechanical seal faces to be carbon on ceramic. The motor shall be non-overloading at any point on pump curve.

3. The motor shall be of the open, drip-proof, sleeve-bearing, quiet-operating, rubber-mounted construction. Motors shall have built-in thermal overload protectors. (Exception—PD models with 3-phase motors, see paragraph 4.)

4. For PD models with 3-phase motors, add the following: The Contractor shall furnish and install a magnetic starter for each booster pump, with at least two thermal overload protectors. The starter shall be equipped with manual reset buttons.

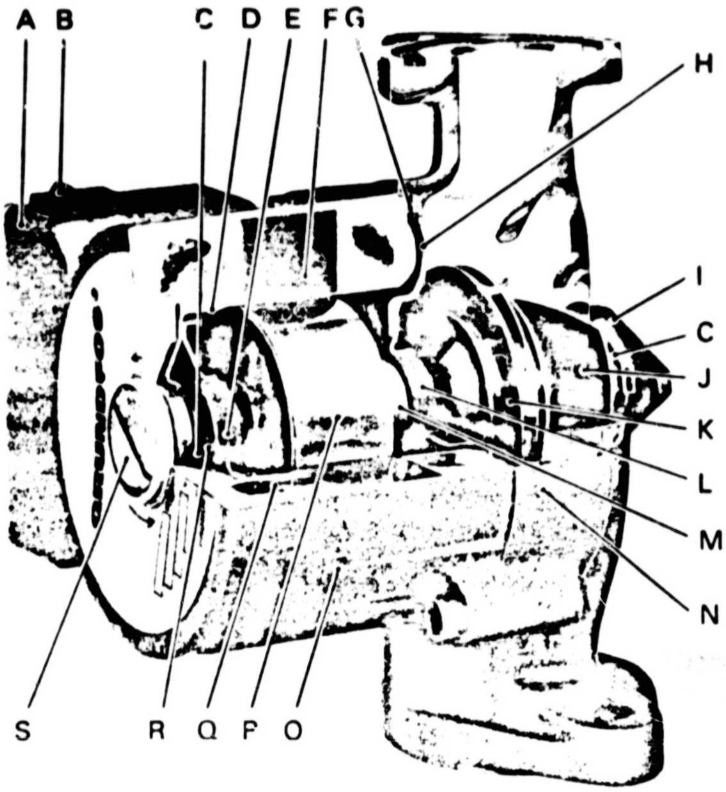
The pump shall be Bell & Gossett Model No. __________, or approved equal with a capacity of __________ GPM at __________ Ft. head when directly driven through a self-aligning flexible coupling by an oil-lubricated motor, ________ volts ________ cycle ________ phase(Ø).

PRINTED IN U.S.A. J-77

BELL & GOSSETT ITT
8200 N. AUSTIN AVE. · MORTON GROVE, ILL. 60053
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

GRUNDFOS | VARIABLE HEAD CIRCULATOR PUMPS | UPS 20-42

A. Terminal Box
B. Switch
C. O-rings
D. Rotor Can
E. Top Bearing
F. Stator
G. Gasket
H. Bearing Plate
I. Flow Adjustment Arm
J. Variable Flow Adjustment Plate
K. Impeller
L. Bottom Bearing
M. Thrust Bearing
N. Pump Chamber
O. Stator Housing
P. Rotor
Q. Winding Protection
R. Shaft
S. Plug/Indicator



INFORMATION: Two-speed circulator pump — UPS 20-42

The UPS 20-42 is fitted with a variable flow control and also features a two-speed motor. The head is controlled by the flow adjustment arm (I) and the choice of speed is made by hand on the switch (B) or made automatically in conjunction with remote control.

CONSTRUCTION

The UPS 20-42 is a water lubricated pump. However, in order to protect the rotor (P) and bearings (E,L) from damaging impurities which may be present in the circulating water, they are separated from the stator (F) and the pump chamber by a liquid filled rotor can (D). The motor shaft (R) extends out from the rotor can, into the pump chamber through the aluminum oxide bearing (L), which also functions as a seal. During initial operation, the pump is automatically self-vented; however, due to the isostatic principle, there is no further recirculation of water into the closed rotor can. The pump's "diamond-hard" aluminum oxide bearing construction, combined with the high starting torque of the motor, ensures re-start after shutdown.

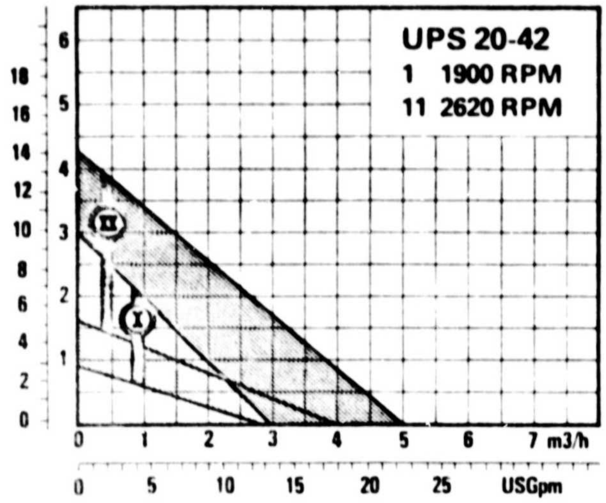
MATERIALS

Stainless steel: . . . . Rotor can, shaft, rotor cladding, bearing plate, impeller, variable flow adjustment plate, thrust bearing cover.
Aluminum oxide: . . . . Top bearing, shaft ends, bottom bearing.
Aluminum: . . . . Stator housing.
Carbon/aluminum oxide: . . . . Thrust bearing.
Cast iron: . . . . Pump housing.
Ethylene/propylene rubber: . . . . O-rings, gasket.
Silicone rubber: . . . . Winding Protection.

APPLICATIONS

The UPS 20-42 should only be used in closed systems (i.e. solar, hydronic) for the circulation of water. However, solutions such as ethylene glycol can be used without hindering pump performance. For open systems, order the Grundfos model UP 25-42 SF which has an all stainless steel pump housing.

PERFORMANCE CURVES UPS 20-42



The UPS 20-42 has a versatile performance range due to the variable flow control and the dual RPM switch. The high and low RPM settings are marked I and II respectively.
Contact Grundfos for information regarding larger circulator pumps and twin pumps.

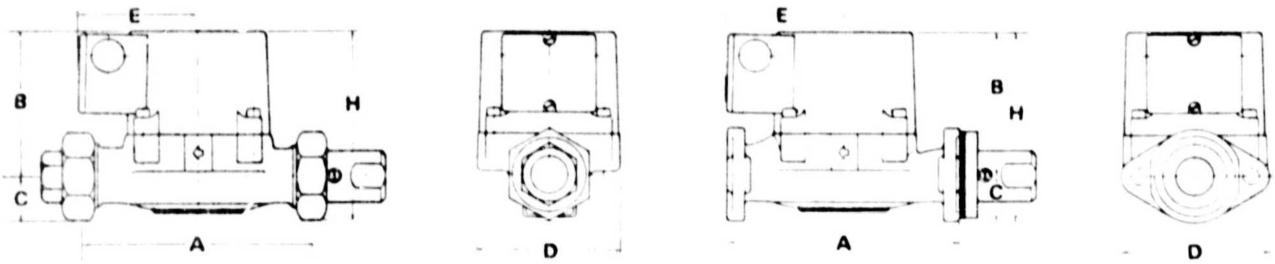
ELECTRICAL DATA

The UPS 20-42 is operated by an energy-conserving 1/20 HP motor which has built-in overload protection. The amperage on setting "I" is 0.65 and 0.85 on setting "II".

DIMENSIONS

UPS 20-42U

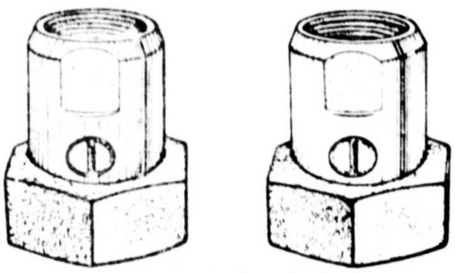
UPS 20-42F



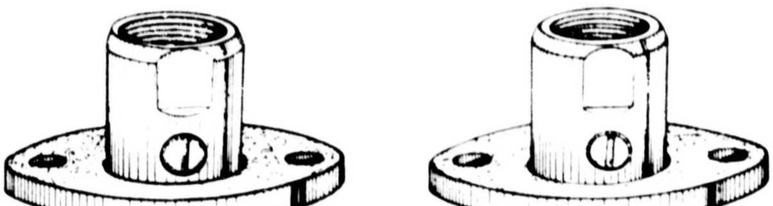
Type	A mm inches	B mm inches	C mm inches	D mm inches	E mm inches	H mm inches	Ship. Carton 1xwxh mm/"	Pack Vol. m^3 Cb. ft.	Weight Kg Lbs.
UPS 20-42U (w/unions)	180 7 1/16	104 4 1/8	32 1 1/4	102 4 1/16	82 3 1/4	136 5 3/8	200 x 180 x 160 7 7/8 x 7 1/8 x 6 5/16	0.005 1.5	4.32 9 1/2
UPS 20-42F (w/flanges)	165 6 1/2	108 4 1/4	33.5 1 5/16	108 4 1/4	82 3 1/4	137 5 7/16	200 x 180 x 160 7 7/8 x 7 1/8 x 6 5/16	0.005 1.5	4.32 9 1/2

ISOLATION VALVES

GRUNDFOS recommends the use of isolation valves with circulation pumps in all systems.



Union Isolation Valve

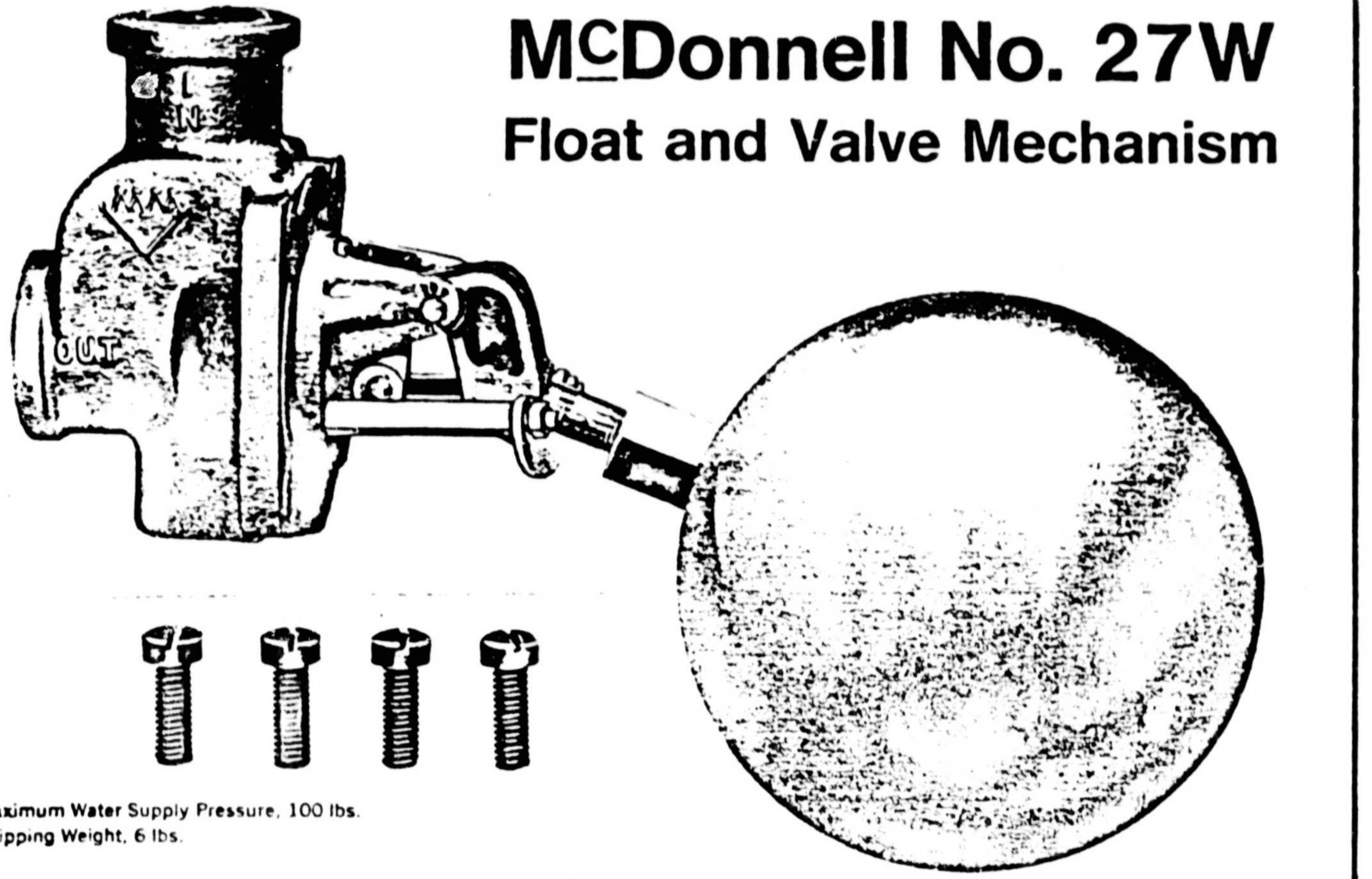


Flange Isolation Valve

ORDER NUMBERS

		Unions		Flanges		Flange Valves Union Valves	
Type	Order No.	Dim.	Order No.	Dim.	Order No.	Dim.	Order No.
UPS 20-42F (w/flanges)	51 22 31 13	3/4" 1"	51 95 21 51 95 22	3/4" 1"	51 96 01 51 96 02	1"	51 97 72
UPS 20-42U (w/unions)	51 02 31 13			1¼" 1½"	51 96 03 51 96 04	1"	51 98 72

McDonnell No. 27W
Float and Valve Mechanism



Maximum Water Supply Pressure, 100 lbs.
Shipping Weight, 6 lbs.

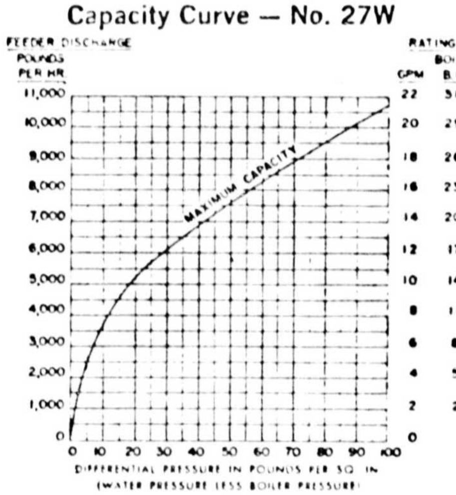
The McDonnell No. 27W Valve Mechanism is a float operated valve that automatically adds water or other liquids whenever necessary to maintain a prescribed level. Its versatility and large feeding capacity fit it for a wide range of applications. Its simplicity of design and quality of construction provide utmost dependability.

The No. 27W Valve Mechanism can be used to add make-up water to condensate receiving tanks, to maintain levels in distillation equipment, and for many other liquid level control jobs. It can be flange-mounted directly in the side of a tank or receiver, to feed water through a separate feed line. It can also be mounted inside, to spill water directly into the tank.

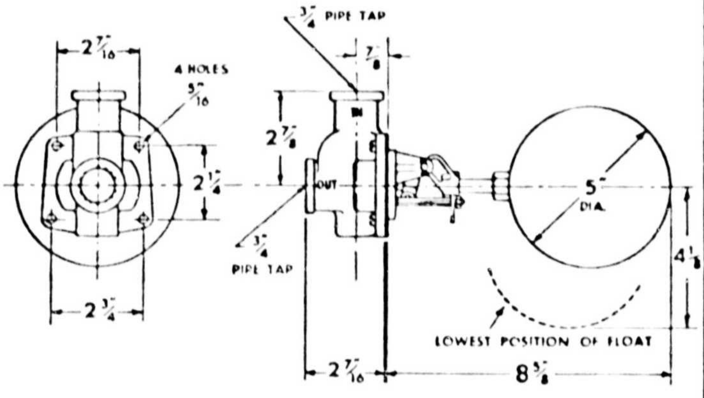
Valve stem seating area is made of high temperature composition. Valve seat is of monel, and located a full 1½" above the closing level. Positive alignment of the valve is assured by the cam-and-roller straight-thrust action, and by the valve guides which are cast as an integral part of the machined valve body.

All parts are of non-corrosive materials, and all bearings unusually husky. The entire valve body is a one-piece brass casting.

Capacity Curve — No. 27W



Dimension Details — No. 27W



McDONNELL & MILLER ITT
3500 N. Spaulding Avenue, Chicago, Illinois 60618

II. ROUTINE MAINTENANCE

Routine maintenance procedures apply generally to the system functions. Components have been selected based upon their past performance and reliability. The piping, wiring, insulation, and mounting hardware have been selected or designed with minimum maintenance and corrosion in mind. The primary maintenance areas are pumps, valves, coating, collectors, and the controller.

A. PUMPS

All pumps used are centrifugal impeller types which are flange mounted. The B & G pumps have an oil point which should be lubricated annually with B & G pump oil. The Grundfos pump is self-lubricating and should not require maintenance. Seals and gaskets should be inspected for leakage once a month. Head and flow rates should be checked annually. This can be done by measuring the inlet and outlet pressure of the pump. This pressure differential is used in conjunction with the manufacturer's pump curve to provide the GPM flow rate. The pressure differential and GPM can be compared to the original specifications. This information is helpful in determining the condition of the mechanical shaft seal, and impeller wear. If the flow rate decreases below the design point, the pump must be rebuilt.

Complete pump failure is caused by a burned out motor winding or other electrical failure. Excessive noise should be investigated with particular attention paid to the motor bearings, shaft seal, and impeller clearance.

B. VALVES

The valves used in this system do not require scheduled maintenance. All valves should be inspected annually to make sure they are operating to the correct position and that they are seating fully. The valves should be inspected monthly for leaks. If a valve appears to malfunction or leak, call a service person.

C. COATINGS

All coatings should be inspected annually for signs of deterioration and corrosion. This includes:

1. storage tank interior coating
2. pipe insulation
3. pipe support hardware
4. collector support hardware
5. insulation covering

C.1 COLLECTOR SUPPORT STRUCTURE

The treated wood battens should be inspected annually for rotting or cracking. A suitable mastic should be applied to problem areas.

All mounting hardware (screws, bolts, and nuts) should be tightened yearly and inspected for corrosion or breakage. Corrosion attacked areas should be sanded to clean metal and coated with a suitable rust preventive paint. Structural cracks should be corrected as necessary.

The mastic and roofing compound on the flat (built-up) roof should be inspected yearly and recoated as necessary.

If the condition of any of the above listed items is questionable, notify Solar Energetics for a determination of procedure for correcting the defect.

D. COLLECTORS

The Revere model 332 solar collectors should not require maintenance but should be inspected periodically. The primary problem areas to be expected are:

1. glass breakage
2. internal leaks
3. header leaks

GLASS REMOVAL

When servicing Revere Sun-Aid units, it may be necessary to remove the glass. The procedure is simple. Loosen the screws holding the cover pieces in place and remove the cover pieces. The use of one or more large suction cups will aid in the removal of glass. If there is broken glass in the unit, a commercial type vacuum cleaner may be useful in removing the small glass pieces. When replacing the glass, be sure the gasket fits snugly around the glass at all points and at the corners. Use a small quantity of silicone sealant at the corners to ensure a weatherproof seal.

II. ROUTINE MAINTENANCE

D. COLLECTORS (continued)

Condensation on the inside of the collector glass is a normal occurrence. The moisture should dry out after one or two sunny days. The condensation is often confused with an internal collector leak. Most leaks will be evidenced by a wet roof area at the base of the collector.

Silicon tubing connects each collector to the sub-header piping. A spring-type hose clamp retains the tubing. It is possible for the clamp to become loose and cause leakage if excess motion is imparted on a collector. Repair is done by removing the surrounding pipe insulation and repairing or replacing the tubing and/or clamps. Check the tubing junction for leaks with the collector pump running before replacing the insulation.

In the event of a collector failure (glass breakage, leak, etc.) the damaged collector may be bypassed by removing the silicon tubing from the collector inlet and outlet nipples, and clamping the tubing with a suitable laboratory pinch clamp. This procedure will permit continuous operation of the collectors while waiting for service.

Collector removal is accomplished by disconnecting the silicon tubing from the inlet and outlet, and removing four stainless steel bolts and nuts holding the collector to the mounting hardware. Gloves should be worn whenever handling the collectors.

E. CONTROLLER

The microprocessor based control unit requires no service other than periodic resetting of the storage registers. The manufacturer or a qualified representative must be called in to troubleshoot or repair the control unit. Tampering with the control unit or its inputs and outputs could cause a failure or system malfunction with catastrophic results. A complete controller operation manual follows.

HIGGINS ENERGY ASSOCIATES SPM-10 CONTROL/MONITOR

Table of Contents

SECTION I

Description

The SPM-10 control/monitor system is designed to act as an independent system control, controlling actuators (dampers, valves, blowers, etc.) based on temperature or input status information as well as to perform monitoring functions on the controlled system. Both control and monitoring are performed by a built-in microprocessor, which also is responsible for displaying and storing data. The unit is designed to operate continuously and to accumulate data for extended periods of time. Recall of data and temperatures is accomplished by an internal keypad, with each data register having its own call number.

The monitoring portion of the unit reads sixteen (16) channels of temperature data each second, converts this data to a farenheit scale and makes it available for display or computation. Inputs from two (2) flowmeters initiate BTU as well as other computations based on those temperatures. Historical data is accumulated and stored in memory for later recall. Special monitoring functions, such as the Hi-Lo function, are incorporated in the monitoring software to facilitate trouble-shooting and for historical monitoring. Data registers accumulating data maintain a running count and may be recalled at any time without disturbing the further accumulation of data.

The control portion of the device controls actuators based on temperatures and input status information under program control of the microprocessor. Display of output control status is accomplished by LEDS on the front panel of the SPM-10. Sixteen (16) temperature inputs and eight (8) input status channels provide the data from which the

device makes output status decisions under program control. The control program is activated and updates control outputs once each interval with intervals programmable from 1 to 9999 seconds.

An internal battery maintains accumulated data during power outages for a period of up to 24 hours. Manual control of all outputs is provided from manually operated switches within the SPM-10.

Housed in a waterproof enclosure, the SPM-10 is designed to operate in harsh environments. The gasgeted, hinged screw cover provides absolute protection from weather as well as tampering, while the keypad is protected from dust and moisture by a flexible plastic barrier.

All control and monitor functions of the SPM-10 are under software control with each control program specific to the end user. Special monitoring and control functions and computations are programmed into the device per the requirements of the end user.

SECTION II

Control Functions

A. Inputs

The SPM-10 accepts inputs of two (2) types; temperatures and on-off status. The thermistor-type temperature sensors utilized have been chosen for their high degree of accuracy, interchangeability, and compatibility with enviornmental conditions. The small sensors are mounted in a ½"x½"x¼" aluminum block for stress protection, then mechanically mounted on the device to be monitored in good thermal contact with the source of heat. The input circuitry along with the software in the SPM-10 decodes the current levels returned from these sensors and translates them into accurate temperatures ($\pm$ .5°F). It is, therefore, necessary that identical sensors be utilized for replacement whenever required. Voltage levels present at the sensors are five (5) volts maximum and change with temperature. Absolute maximum temperature of the sensors is three hundred (300) degrees Farenheit, above which a permanent offset inaccuracy will result. The sensors are not immersion devices and care must be taken to place them a relatively dry enviornment. The SPM-10 accepts up to sixteen (16) such inputs.

On-off status inputs, which are accepted by the SPM-10, are essentially switch closures from external devices such as thermostats, aquastats, switches or relays. The SPM-10 utilizes input status information as an aid to making control decisions. This is accomplished by sending a five (5) volt signal through one wire to the device to be interrogated while the return voltage, or lack of it, is sensed through the other wire. The SPM-10 supplies it's own sense voltage.

Care must be taken, therefore, to maintain complete electrical isolation from any other voltages. The maximum sense current supplied to each switch is five (5) milliamperes D.C.. Eight (8) such status input channels are available, each being read under program control.

B. Outputs

The output section of the SPM-10 consists of sixteen (16) single-pole/ double-throw dry-contact magnetic relays. The output section controls valves, pumps, fans, etc., under program control by switching the appropriate voltage to each device being controlled. Each relay is capable of switching five (5) amperes at up to two hundred fourty (240) volts A.C.. The relays will switch five (5) amperes at up to fifty (50) volts D.C.. The position of each relay is under program control while in the "AUTO" mode, and determined by switch position while in the "MANUAL" mode. Normally-open, normally-closed and common contacts are available to facilitate the design of fail-safe systems, as each relay spring-returns to a normally-closed/ common position. In some systems, a common power bus may be utilized throughout all common relay terminaly. Care must be taken not to introduce high or reverse polarity voltages to any relay contacts whenever a common bus is utilized. Each relay may control any number of devices providing that all devices require identical voltages and that the total current load on each relay is five (5) amperes or less.

C. Auto-control mode

The SPM-10 is capable of making and outputting new control

decisions once per second. Due to thermal lag in sensors and actuator delays, it becomes advantageous to update the controller's outputs only once every five (5) minutes (depending on each system's requirements) to allow temperatures to stabilize and allow actuators to run full-course. This delay action inhibits cycling of pumps and fans whose status depends on temperature levels. Therefore, a programmable time delay of one (1) to nine-thousand nine-hundred and ninety-nine (9,999) seconds determines the frequency of control updates in the SPM-10. Each new control mode will be maintained regardless of the temperature or status information during the programmed interval. When a control update is required, as determined by the interval timer, the control interpreter is activated. The control interpreter reads the specific control program developed for each application, one line at a time, modifying outputs based on temperature, status and program information. The interpreter gives the device the power to execute complex control strategies utilizing hysteresis, positive and negative temperature differentials, input status and time-of-day information. Upon execution of all instructions in any given program, the interval timer is again reset to it's original value and output data is transferred to the output relays. The relays will maintain their position until the interval timer times out and initiates another control update or until manual control of the relays is initiated. Control programs may be modified as required. In some applications, it may be advantageous to "burn" the control program into the memory of the microprocessor, while in others, on-site programming capability is required. The SPM-10 will operate in either mode upon set-up at the factory.

D. Manual-control mode

Each actuator may be controlled manually from within the SPM-10 by it's particular manual override switch. Provision is made for each actuator for "ON", "OFF", or "AUTO", with the "ON" and "OFF" positions representing manual control. One switch controls one relay, which in turn controls the particular actuator wired to it. When a switch is in the manual mode, the microprocessor and control program have no effect upon the associated relay; when in the "ON" position, the switch maintains that relay "on" regardless of the microprocessor commands. The output status display LED's will accurately reflect the output conditions in both the "AUTO" as well as the "ON" and "OFF" modes. When a device is returned to "AUTO" from either the "ON" or "OFF" mode, the device immediately assumes the position determined by the last control update.

E. Control failsafe

In the event of a power outage to the SPM-10, all output relays spring-return to a known, fixed position regardless of the mode of operation. This allows all valves, motors, fans, etc. to remain in a known, fixed position until the restoration of power. The fail-safe position of each actuator device is entirely determined by the wiring between the SPM-10 and the device, specifically, use of the normally-open and normally-closed contacts. In a solar heating application, it can be seen that return to a backup boiler might be advantageous during power outage or upon failure of of the SPM-10. Incorporated into the circuitry of the device are measures to insure

this type of fail-safe return to a fixed, known mode. Removal of power to the SPM-10 will result in an immediate shift to the fail-safe mode. The output status display LED's may be wired to continue to function even during loss to the SPM-10 by providing power for the display from the actuator power source. In this case, as long as actuators have power, their condition will be apparent from the front panel of the SPM-10.

SECTION III

Monitor Functions

The SPM-10 is designed to monitor the process it 's controlling, to perform computations and to store data such that a cumulative performance record of the process may be recalled at any time without disturbing the further accumulation of data. The specific types of data gathered and stored are under program control with each end-user designing their own specialized program. Presented here will be one such program.

The SPM-10 utilizes a data register concept much like that used in many hand-held calculators today. Each data register has a fixed length and contains a complete number. A data register may contain a temperature, time or quantity of heat. Data registers have a unique number associated with them that may be thought of as a call number, with each register having it's own number, Data registers are recalled to the SPM-10 display from the front-panel keypad by first entering the call number of the desired register followed by an "E" (representing "enter"). The display will instantly reflect the contents of that particular register and will remain until a new register is recalled. The data contained in the displayed register will be updated to reflect the most recent information available.

The following data is available in register format:

1. Sixteen instantaneous temperatures.
2. Highest temperature excursion of each of the sixteen temperature sensors.
3. Lowest temperature excursion of each of the sixteen temperature sensors.

4. Accumulated BTU's, loop "A".

5. Accumulated BTU's, loop "B".

6. Elapsed time since last reset.

Each function will be discussed below.

Instantaneous temperatures. (Sixteen (16) each, registers 01 through 16)

These registers reflect the instantaneous temperatures in degrees farenheit of each of the sixteen (16) sens[illegible] updated once per second. The decimal point is implied such that the least significant digit represents one-tenth (.1) degree farenheit. Accuracy of the displayed temperature is plus or minus one half ($\pm$ .5) degree farenheit, resolution being one-half (.5) degrees farenheit.

Lowest temperature excursion. (Sixteen each, registers 21 through 36)

These registers reflect the lowest temperatures attained by each of the sensors since last reset, compared and updated once per second. Accuracy and resolution are identical to instantaneous temperatures.

Highest temperature excursion. (Sixteen each, registers 41 through 56)

These registers reflect the highest temperatures attained by each of the sensors since last reset, compared and updated once per second. Accuracy and resolution are identical to instantaneous temperatures.

Accumulated BTU's, loop "A". (Registers 38 & 39)

These registers reflect the accumulated total BTU's generated or delivered through thermal sink "A". A flow meter measuring flow in thermal loop "A" provides a pulse to the SPM-10. Upon recieving the

pulse, the SPM-10 initiates an interpreter similar to the control interpreter whose function is to perform those computations written into the math program, line by line, until all the math has been performed and the results stored in their proper locations. Due to the programmable nature of the device, various configurations of flowmeter, flow factors and system constants may be entered for computation. In some applications, it may be desirable to "burn" the math program into the microprocessor's memory, while other times, the programmable feature is required for on-site modifications. The SPM-1 is designed to operate in either mode upon set-up at the factory.

A single BTU computation is made with each flow pulse utilizing the most recent temperature data. The result is added to the "BTU A" register, resulting in a running-count with single unit resolution. Six (6) digits of data are displayed at a time. The SPM-10 maintains ten (10) digits of BTU data internally, so that the complete number is viewed as two separate registers, each with it's own call number. One register contains the BTU count in units ($x10^0$) while the other contains the count in million ($x10^6$) plus the sign of the number. Stringing the two numbers together delivers the true count with a range of plus or minus 10^{11} while maintaining resolution of a single count.

The BTU registers deliver a signed number ten (10) digits in length. The sign of the number represents the direction of flow into or out of the thermal sink. While the BTU total may at one time be a positive number, temperature conditions might reverse, reversing the heat flow through the sink. The SPM-10 will automatically

accumulate BTU's, both gains and losses, and represent gain or loss as positive or negative numbers. A heat gain followed by an equal heat loss through the same load will result in a zero (0) BTU reading.

Flowmeter factors specific to the type of flowmeter utilized in each loop are programmable to allow use with air, oil, and various types of heat transfer medium flowmeters. These factors, like the math program, may be "burned" into the memory of the microprocessor or may be altered on-site, depending on the set-up at the factory. The "A" loop BTU circuitry contains an internal programmable divider that may be preset to operate with turbine-type flowmeters and other high frequency output devices. When the preset number of pulses has occured, one pulse is delivered to the microcomputer to initiate the math interpreter.

Accumulated BTU's, loop "B". (Registers 18 & 19)

The "B" section BTU registers are identical in function and design as the "A" section with the following exceptions;

1. The "B" section measures an entirely separate thermal loop, with separate temperature sensors and a separate flowmeter. The device may be configured to monitor the same thermal loop with one set of registers for heat gain and the other for heat loss while both share the same flowmeter.

2. No divide circuitry is available on the "B" loop.

Readout of both loops is accomplished in the same manner, with differing register numbers.

Elapsed time (Registers 58 & 59)

Two (2) registers are devoted to maintaining the elapsed time since last reset. Register number fifty-eight (58) displays in (right to left) seconds, minutes and hours in a twenty-four (24) hour format. Register number fifty-nine (59) maintains a count of days since last reset with a maximum count of nine-thousand nine-hundred and ninety-nine (9,999) days. The clock is updated once per second by an internal crystal time base.

B. Monitor fail-safe mode.

Upon loss of utility power, the SPM-10 initiates an orderly shut-down of the microprocessor and halts further accumulation and display of of data until power returns. Upon the resumption of power, the SPM-10 will automatically restart picking up where it left off when halted with all register data maintained by an internal battery. Data may be retained in this manner for up to twenty-four (24) hours, after which, loss of data occurs. The elapsed time clock will be halted during the power loss and will restart from the previously accumulated time upon resumption of power. No operator assistance is required to restart the SPM-10 as a result of power outage.

C. Restart and Restart & clear functions.

Restart of the SPM-10 may be accomplished manually by depressing

the "RESTART" button. The SPM-10 will begin operating utilizing previously stored data as a starting base. A "RESTART & CLEAR" sequence is required to start the unit with all registers cleared. The "RESTART & CLEAR" sequence is accomplished by depressing the "C" (clear) key on the keypad and the "RESTART" button simultaneously, then releasing the "RESTART" button. The unit will immediately start with all registers cleared. This precise sequence eliminates accidental reset and is also required after repair or modification to the unit or whenever the internal battery is removed or discharged. The "RESET & CLEAR" sequence affects the internal registers in the following manner;

1. Instantaneous temperatures. Begins machine operation, instantaneous temperatures updated once per second.
2. Low temperature excursion registers. Clears old lows, resets lows according to present temperatures. Begins comparison and updates once per second.
3. High temperature excursion registers. Clears old highs, resets highs according to present temperatures. Begins comparison and updates once per second.
4. Accumulated BTU's, loop "A". Clears to zero (0).
5. Accumulated BTU's, loop "B". Clears to zero (0).
6. Elapsed time. Clears to zero (0).

Again, the "RESTART" button does not affect the contents of any registers, it simply restarts the SPM-10 from a previous data base.

The control portion of the SPM-10 will respond to a "RESTART & CLEAR" sequence by initiating an immediate control program sequence, making all new control decisions and outputting the appropriate voltage levels to the actuators based on the temperature and input status information available to the unit at the time of the "RESTART & CLEAR". The next control program sequence will occur after the pre-programmed interval has elapsed.

SECTION IV

Maintenance

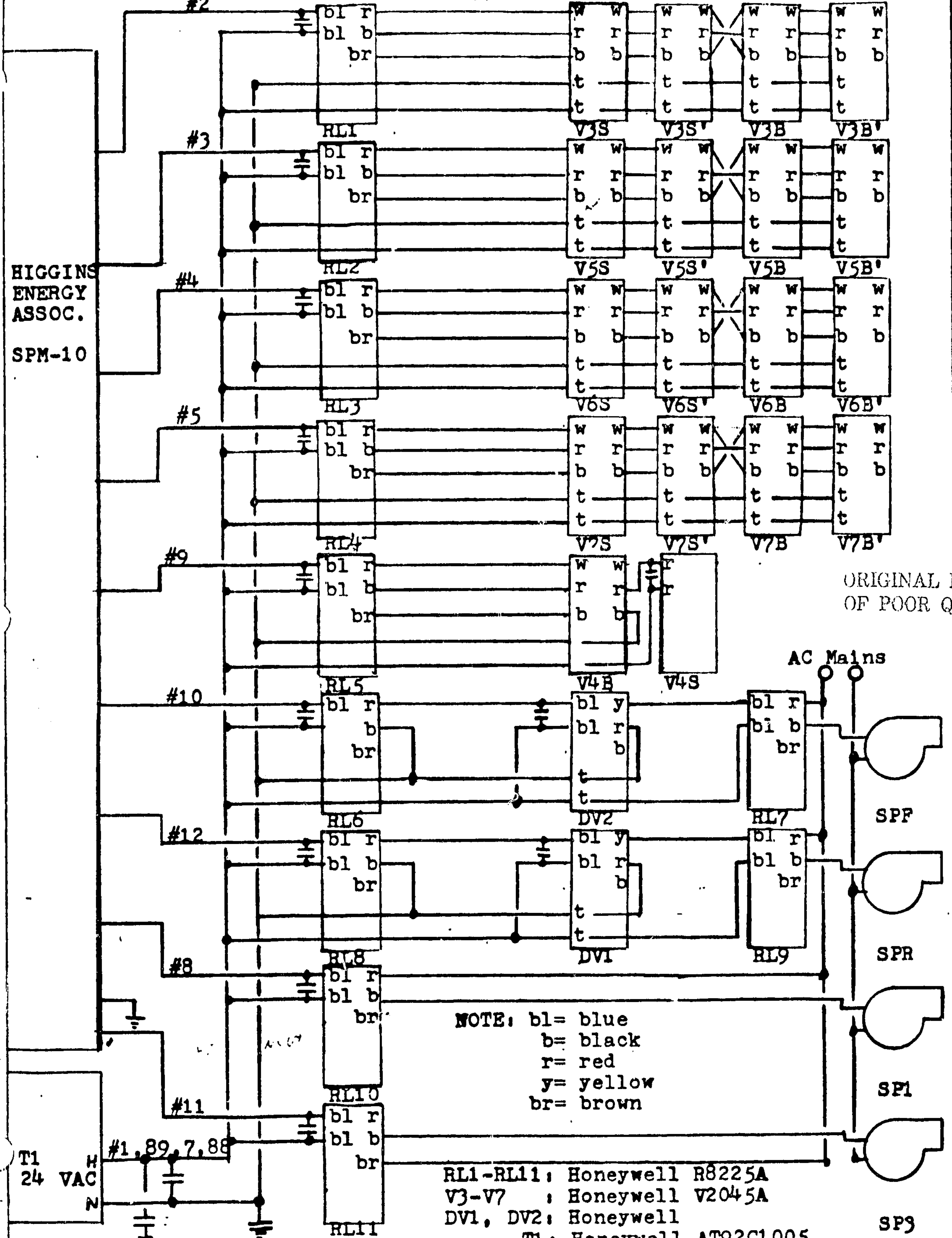
The SPM-10 will operate for an indefinate period of time unattended. Should problems occur in the operation of the device, Higgins Energy Associates, or it's appointed designee should be notified. No attempt should be made to repair the unit or replace parts in the device as costly damage could result. No regular maintenance is required, however, the contents of all registers as well as output status should be examined and noted once per month. This procedure will expose faults in the SPM-10 as well as failures of actuators, piping, etc.. Should any of the accumulated registers approach their maximum counts ($\pm$ 10^{11}BTU, 9,999 days), the "RESTART & CLEAR" sequence should be initiated with previous data noted as values above those limits are undefined.

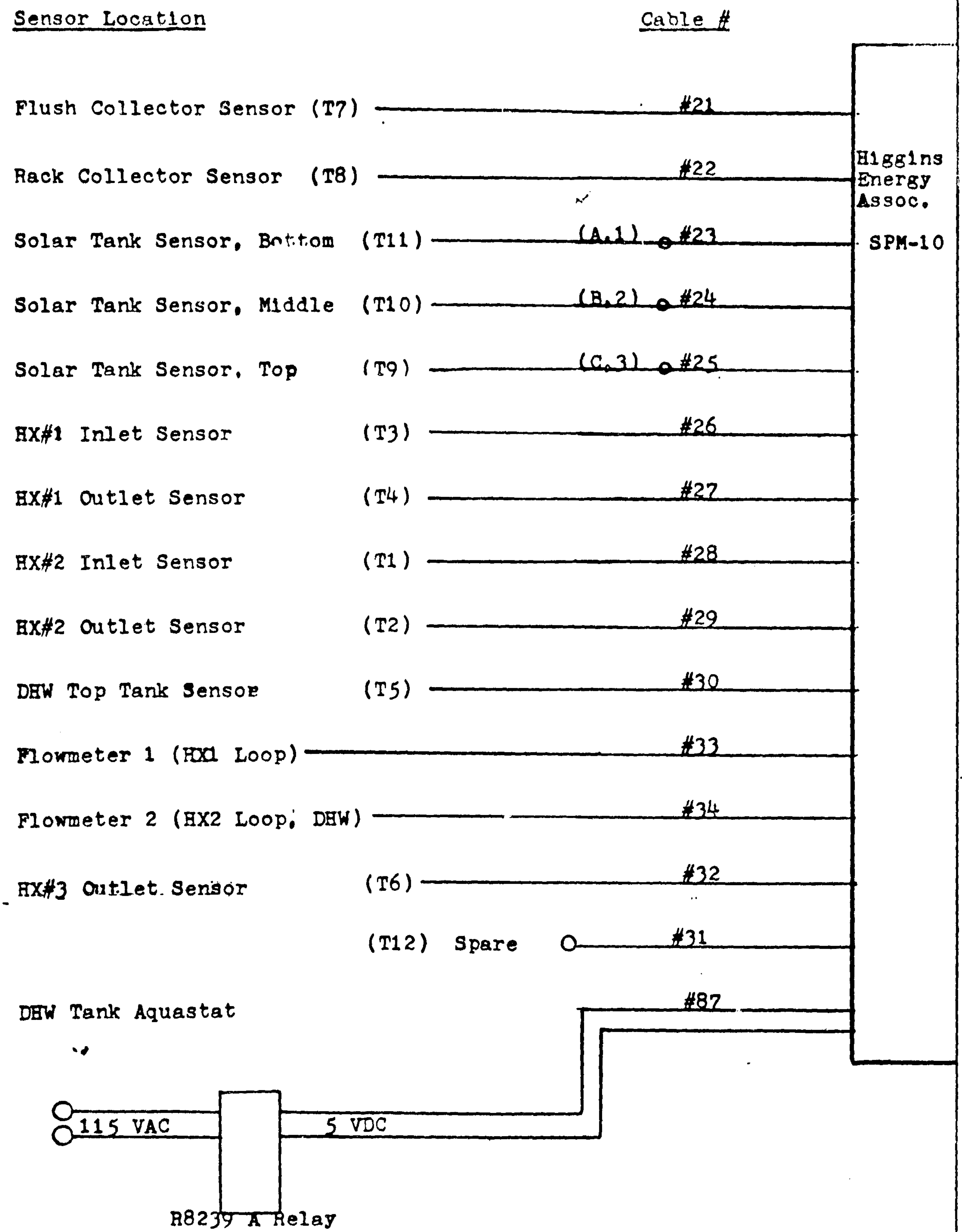
SECTION V

Warranty

The Higgins Energy Associates SPM-10, including any options, are warranted against defects in materials and workmanship for one year from the date of purchase for parts and three months from the date of purchase for labor. During the warranty period, Higgins Energy Associates will at it's option repair, replace or make a full refund for any unit which proves to be defective, has not been misused, abused or tampered with. Higgins Energy Associates is not responsible for consequential damages as a result of faulty SPM-10 operation and in any case is liable only up to the purchase price of the controller. No other warranty express or implied, including warranties of merchant ability or fitness for a particular purpose, is made.

In the design and construction of the SPM-10, the full intent of the specification will be met. Higgins Energy Associates, however, reserves the right to make, from time to time such alterations from the detail specification as may be required to permit improvements in the design of it's products and assumes no obligation to introduce those improvements into products previously sold.


#2
#3
#4
#5
#9
#10
#12
#8
#11
#1,89,7,88
HIGGINS ENERGY ASSOC.
SPM-10
T1 24 VAC
H
N
RL1
RL2
RL3
RL4
RL5
RL6
RL7
RL8
RL9
RL10
RL11
V3S
V3S'
V3B
V3B'
V5S
V5S'
V5B
V5B'
V6S
V6S'
V6B
V6B'
V7S
V7S'
V7B
V7B'
V4B
V4S
DV1
DV2
AC Mains
SPF
SPR
SP1
SP9
NOTE: bl= blue
b= black
r= red
y= yellow
br= brown
RL1-RL11: Honeywell R8225A
V3-V7 : Honeywell V2045A
DV1, DV2: Honeywell
T1: Honeywell AT92C1005



Note: All cables are two conductor, second conductor grounded at SPM-10

SECTION VIII

Readout Key Legend

Function	Register Number		
	Present	Low	High
HX#2 Inlet temperature	01	21	41
HX#2 Outlet temperature	02	22	42
HX#1 Inlet temperature	03	23	43
DHW top tank temperature	05	25	45
HX#3 Outlet temperature	06	26	46
Flush Coll. temperature	07	27	47
Rack Coll. temperature	08	28	48
Top solar tank temperature	09	29	49
Middle solar tank temperature	10	30	50
Bottom solar tank temperature	11	31	51
Spare	12	32	52
Calibrate (157)	16	36	56
BTU delivered, DHW loop x 10^0	18	-	-
BTU delivered, DHW loop x 10^6	19	-	-
BTU delivered, main loop x 10^0	38	-	-
BTU delivered, main loop x 10^6	18	-	-
Elapsed time, hr/min/sec	58	-	-
Elapsed time, days	59	-	-

PHOTOGRAPHS OF INSTALLATION

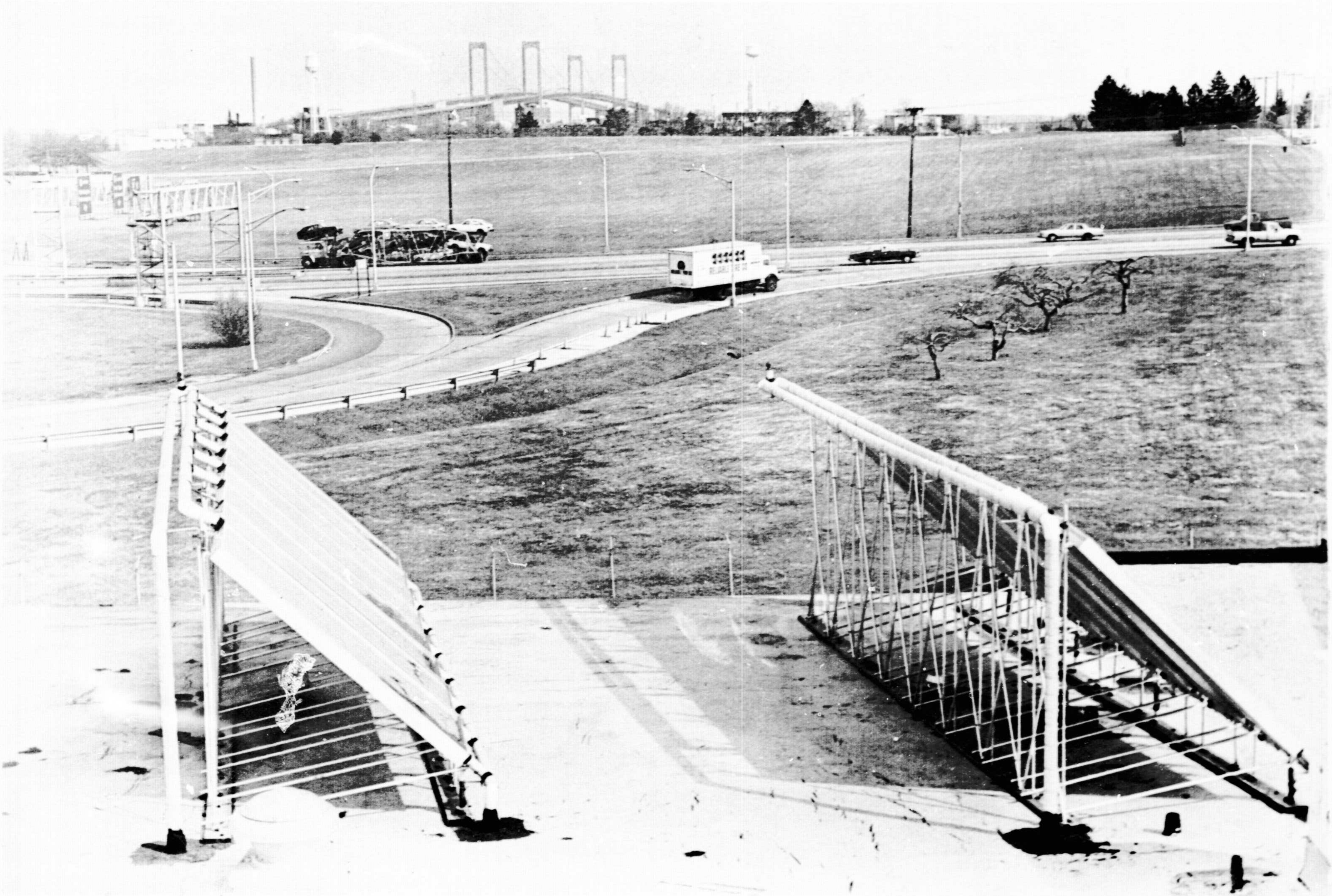
LIST OF PHOTOGRAPHS

FIG. 10

FIG. 11

Fig 12

FIG. 13



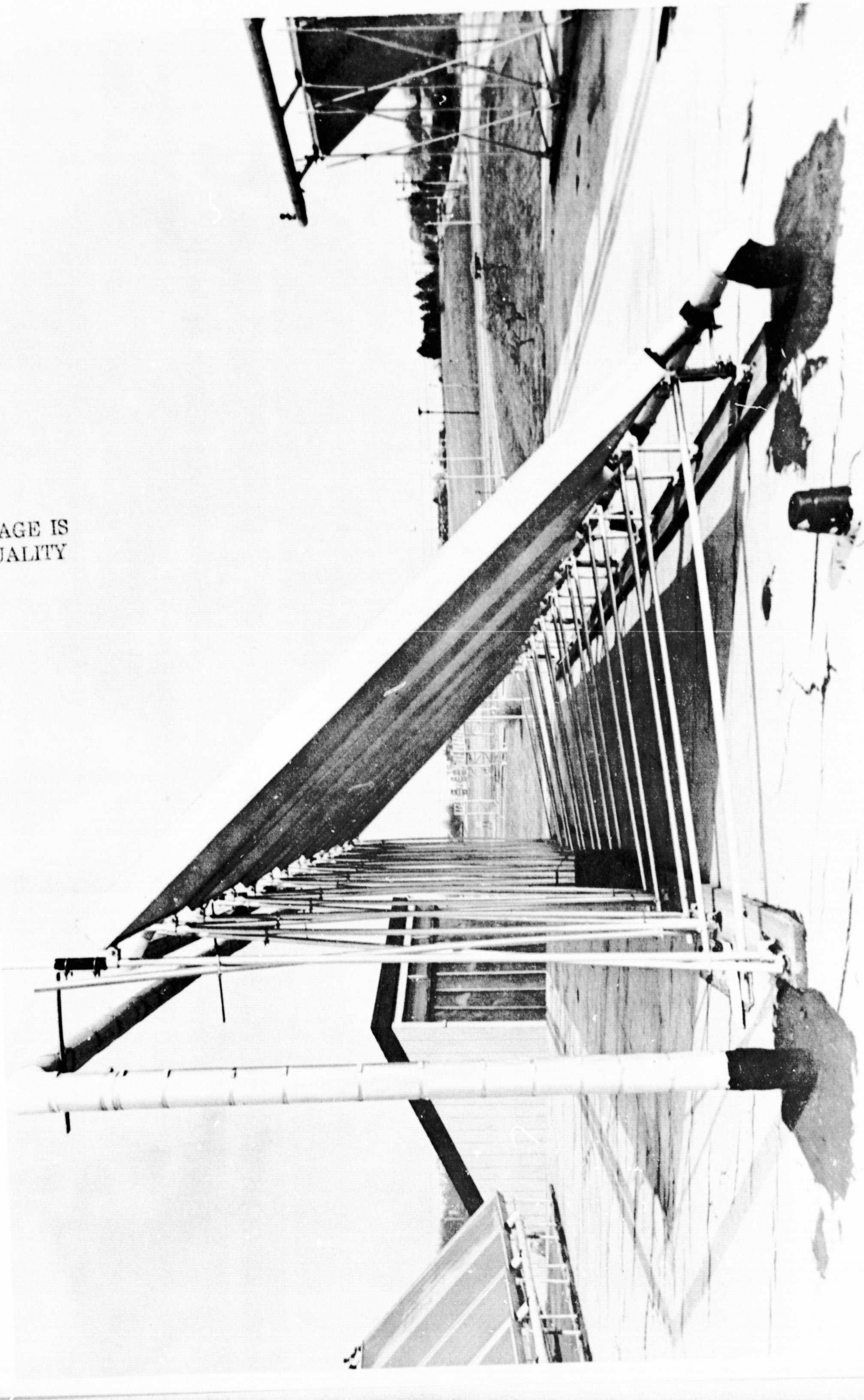
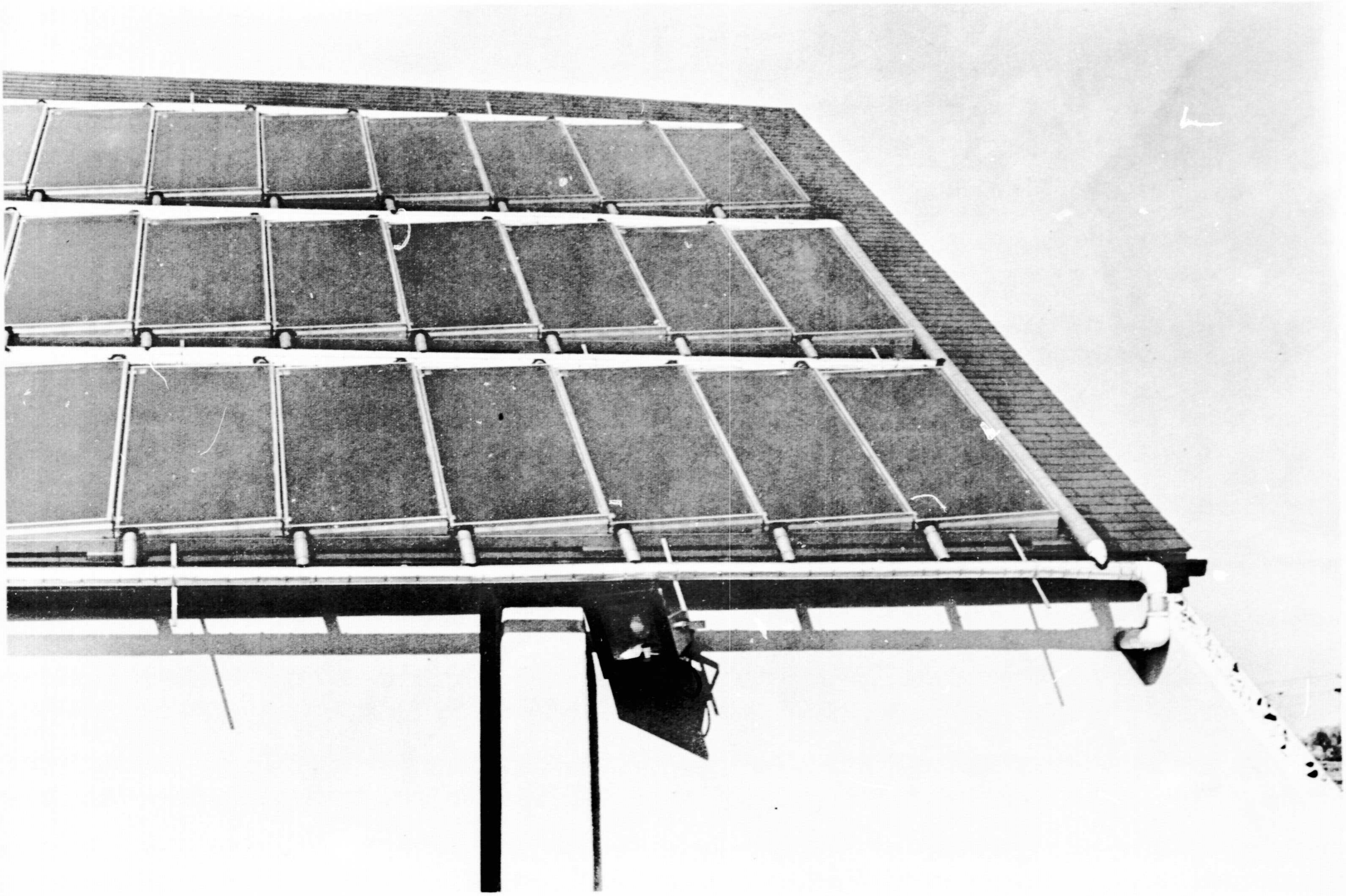


FIG. 14

FIG. 15



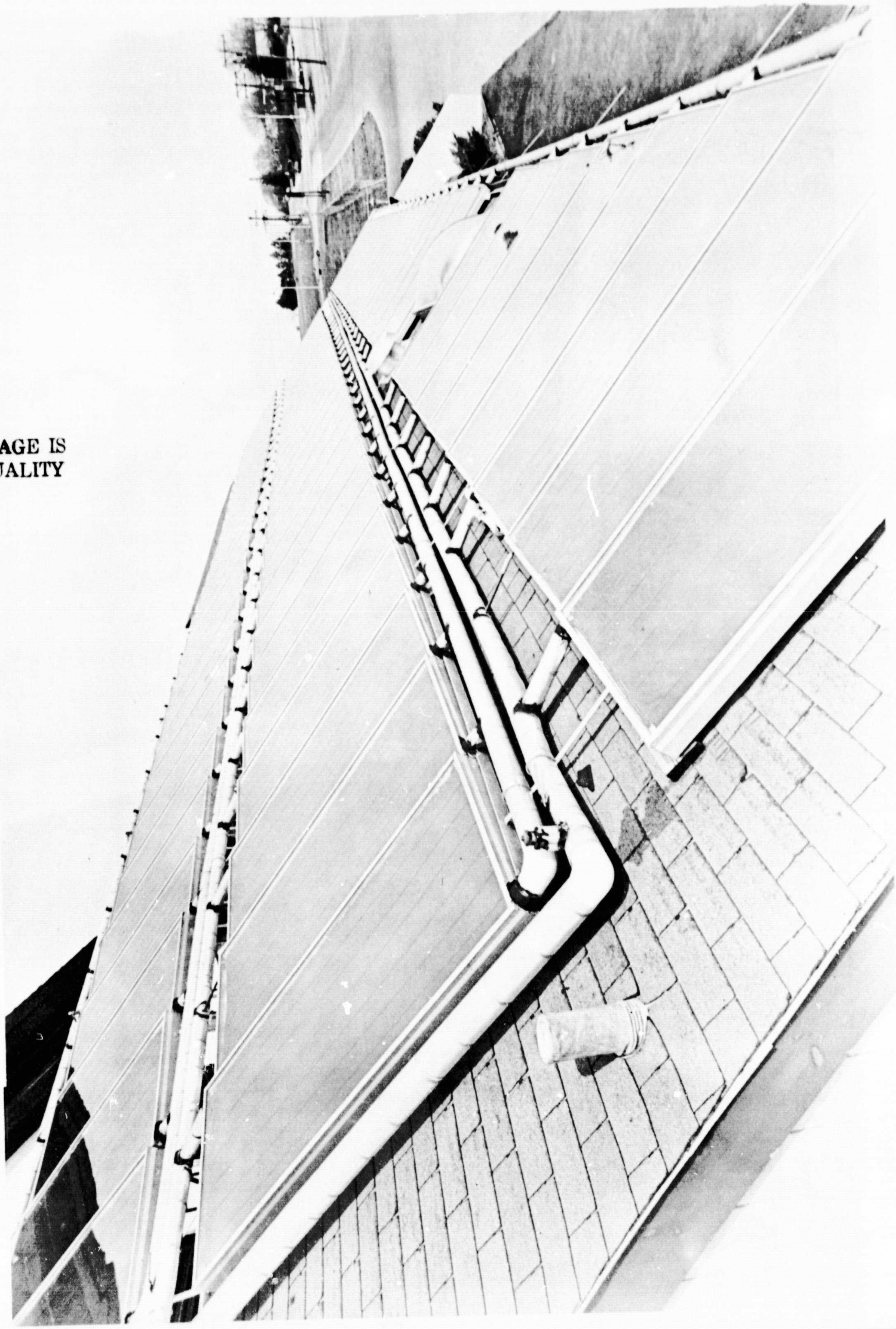
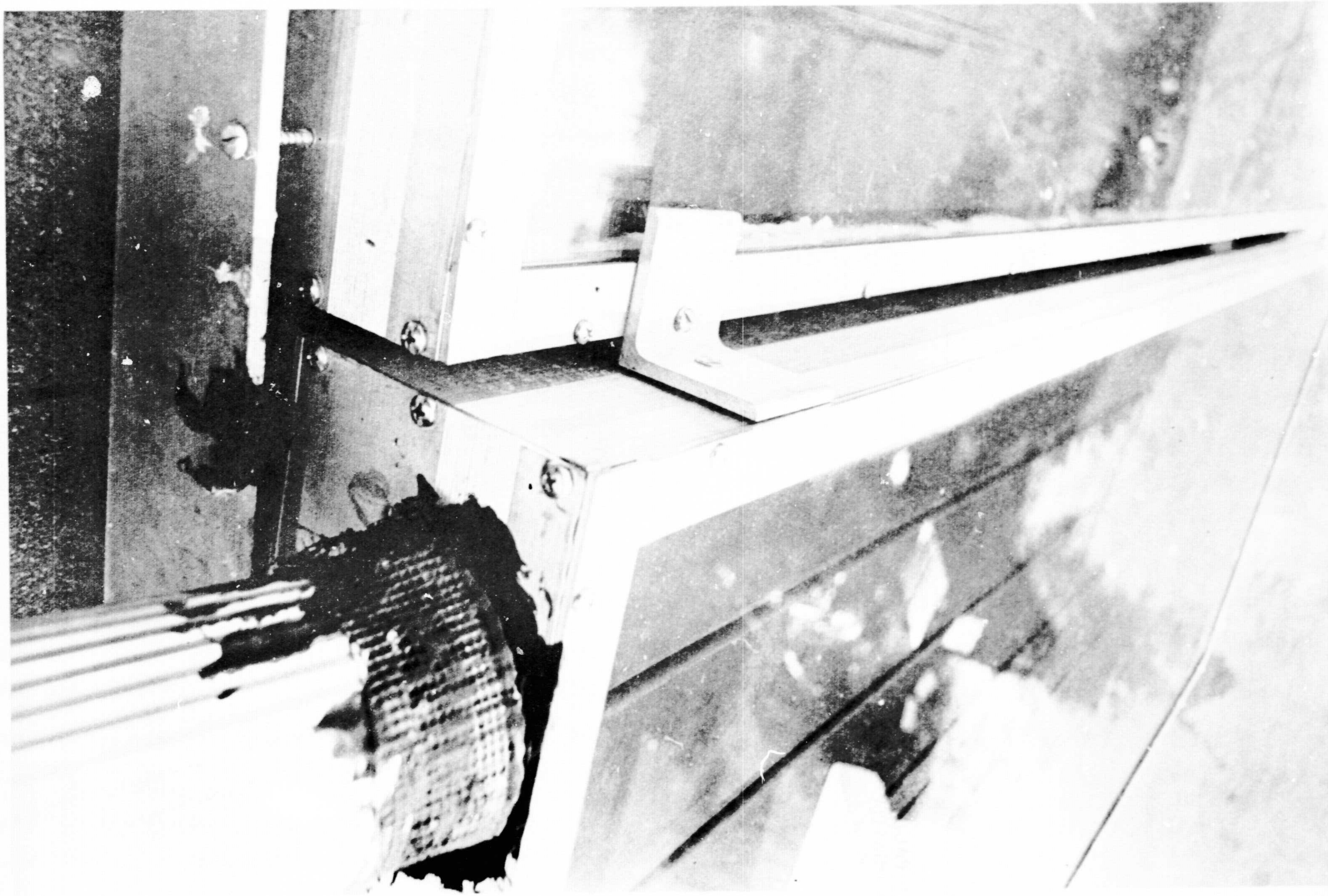
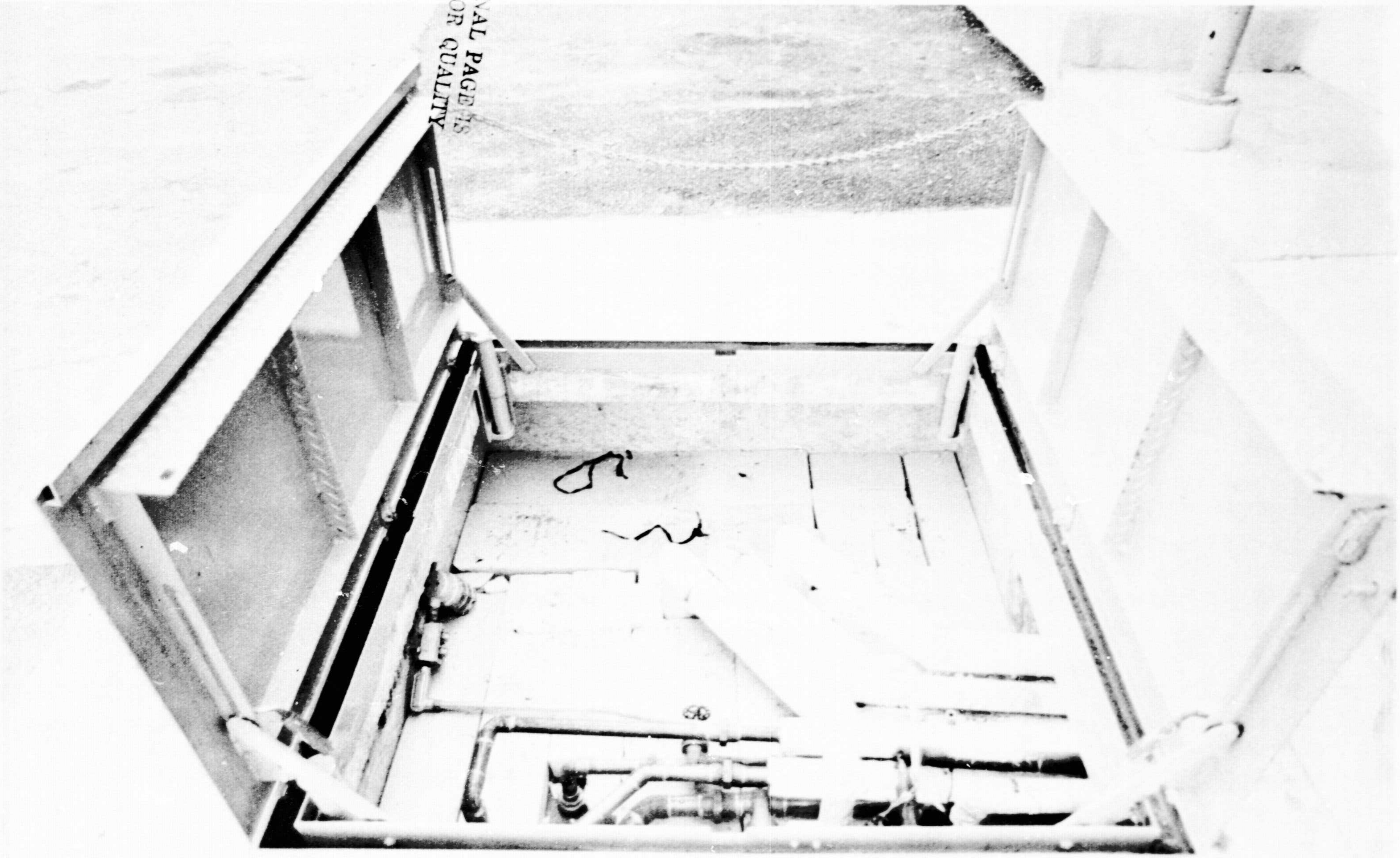


FIG. 16

FIG. 17



FIG, 18



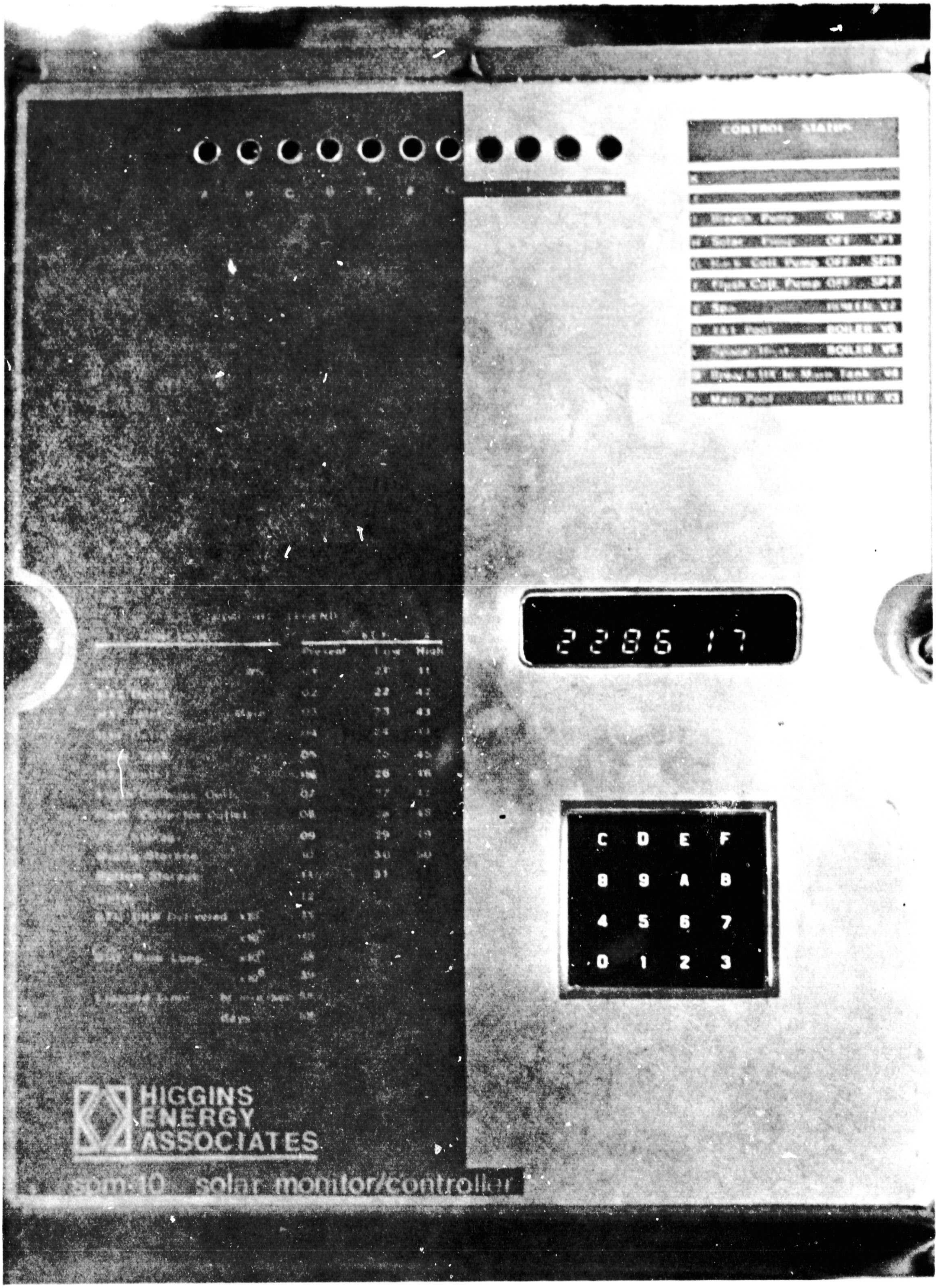

CONTROL STATUS
2286 17
Present Low High
C D E F
8 9 A B
4 5 6 7
0 1 2 3
HIGGINS
ENERGY
ASSOCIATES
som-10 solar monitor/controller

FIG. 19

FIG 20

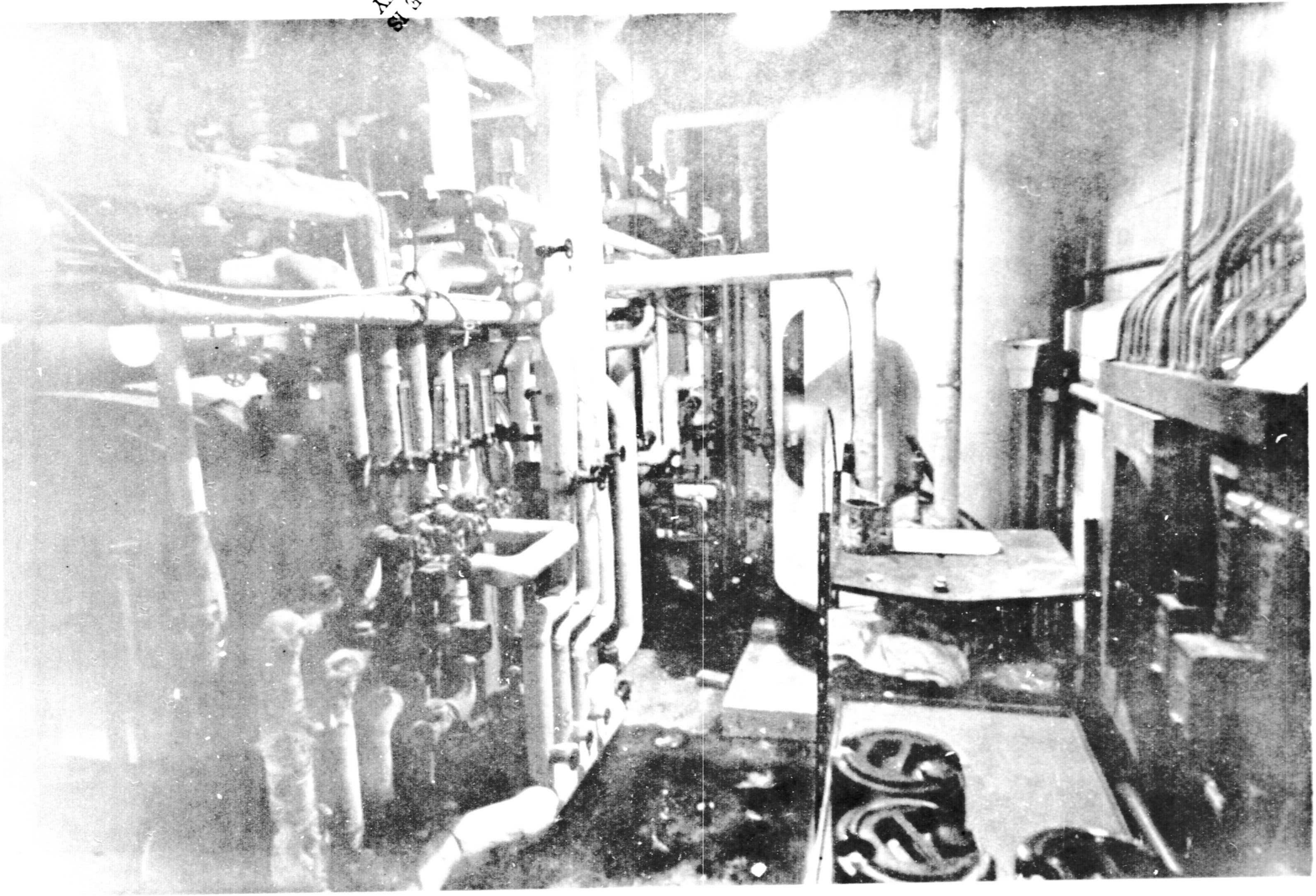


FIG 31

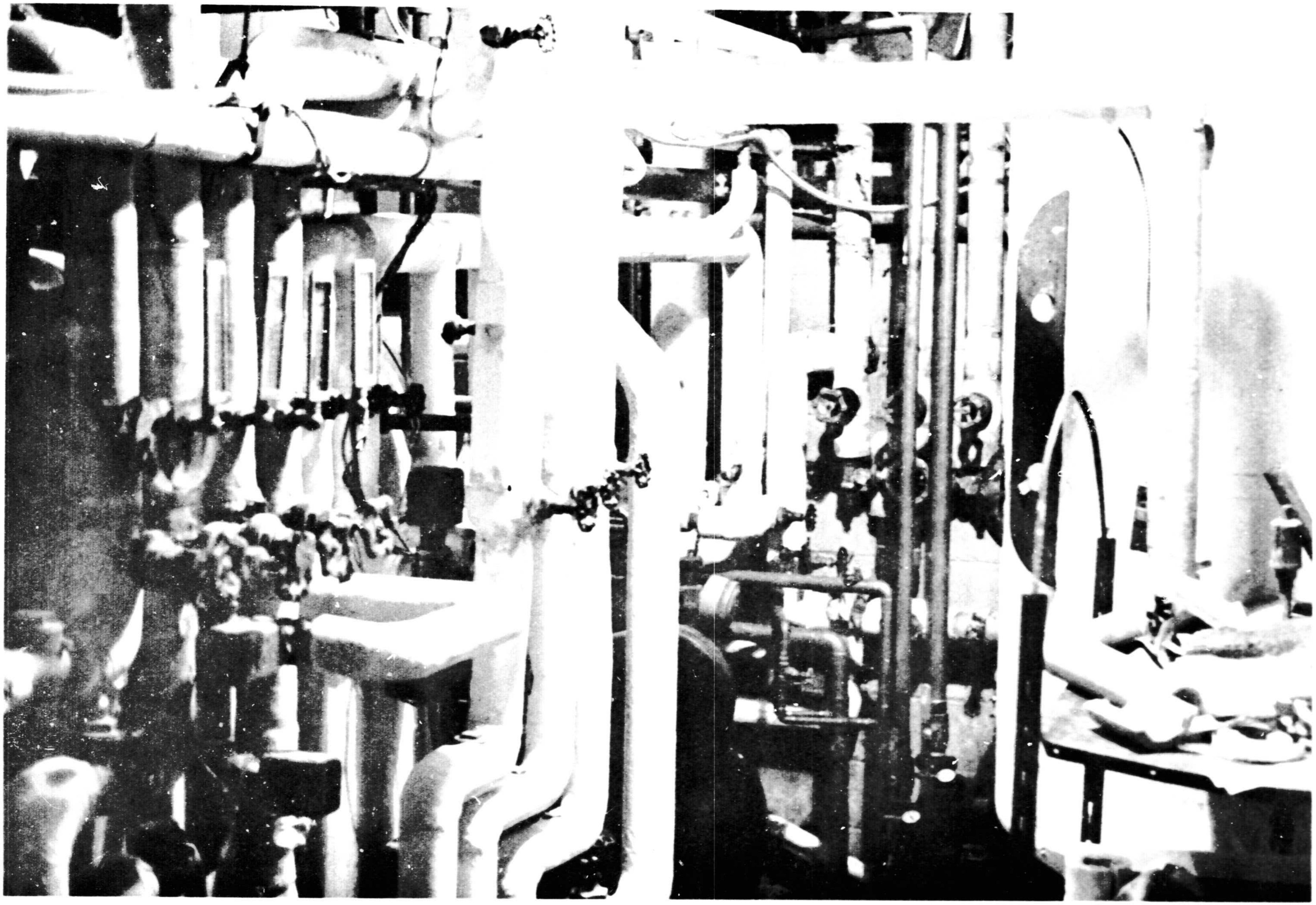
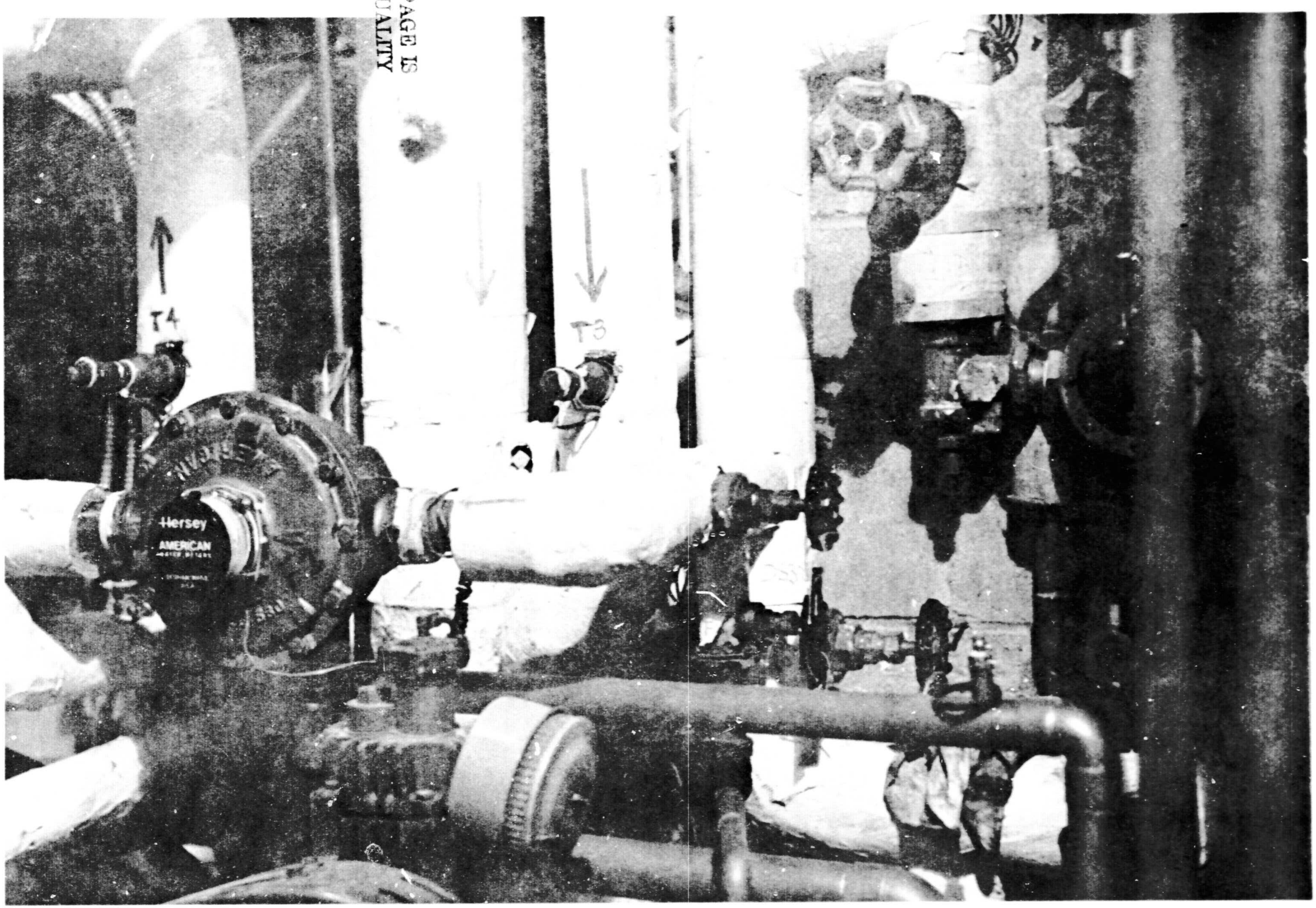


FIG. 22



8. PREDICTED PERFORMANCE DATA

EXISTING ENERGY DEMAND

The existing energy demand for the Wilmington Swim School, based on the actual amount of fuel consumed over the last five (5) years, does not provide meaningful data because the owner kept the rate of consumption "artificially" depressed. During the summer months the boiler would usually be turned off completely, eliminating pool heating and all domestic hot water. During the winter months, outside ventilation was sharply reduced to retain heat. For these reasons, energy calculations have been computed based on "normal" use of the building. (The Δ t of 80 degrees F. reflects the fact that the space in a pool is kept warmer than the average building). Based on "normal" usage, then, the energy used in the existing building is:

$$\text{Total} = 2{,}574 \times 10^6 \text{ BTU}$$

$$\text{BTU/GSF/YR} = \frac{2{,}574 \times 10^6 \text{ BTU}}{12.50 \times 10^3 \text{ GSF}} = 205.92 \times 10^3 \text{ GSF/YR}$$

These figures are based on the following:

(1) Domestic water heating is based on an estimated 44,400 gallons per month or 532,800 gallons per year. Using a water temperature rise of 50 degrees F., the heat load is 222×10^6 BTU.

(2) The heat required for the pool is calculated to be 1156×10^6 BTU annually.

(3) The heat required due to conduction through the building is based on a computed heat loss, with a temperature difference of 80 degrees F., of 457,000 BTU per hour. This is equivalent to an annual heat loss of 514×10^6 BTU.

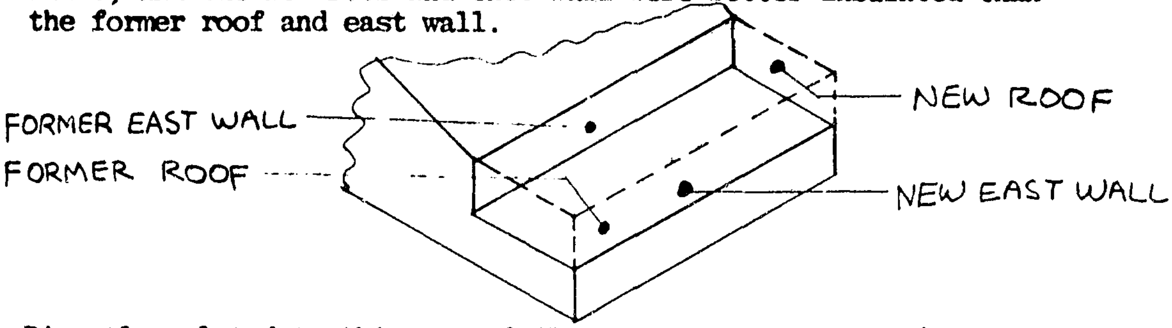
(4) The heat required due to ventilation air is computed to be 606,000 BTU per hour which is equivalent to 682×10^6 BTU/year.

(5) Summary:

Domestic Water	222×10^6
Pool Heat	1156×10^6
Conduction	514×10^6
Ventilation	682×10^6
Total	2574×10^6 BTU/year

8. PREDICTED PERFORMANCE DATA (Continued)

The addition to the Swim School has two more or less distinct components. One of these is the enlargement of a small mezzanine to a full second floor over an existing one story section of the School. The primary reasons for this location were functional; nonetheless while this enlarged mezzanine adds about 2,000 square feet to the building, it actually produces a drop in energy loss since there is only a small increase in wall area (at the end walls) and the new roof and east wall were better insulated than the former roof and east wall.



Directly related to this second floor was a small office/conference room element over a new entry. The role of the entry in reducing air changes was described above. The position of this office/entry element was dictated by the existing internal layout of the School. The design and construction of the element and its fenestration are intended to minimize energy demand and its south wall will serve to support the collector for the passive solar energy collector.

The second major component of the addition is a teaching and therapeutic wing along the south side of the existing building. Its location was determined by several factors - projected use of the roof for future installation of solar collectors, suitability for a roof sun deck at one end, proximity to the existing mechanical system to minimize mechanical construction costs and increase mechanical efficiency by keeping piping runs as short as possible, etc. Once its general position was determined, the configuration of this teaching and therapeutic addition was controlled in large measure by zoning and setback requirements. The amount of perimeter wall was minimized by having one side of this component almost totally continuous with the south wall of the existing building. Insulation standards for walls and roofs exceed Ashrae 90.75 standards.

Some of the energy conservation measures for the addition are tied in with the solar energy system. These include: stack heat reclamation, night setback, enthalphy control, and boiler outdoor reset.

An energy budget for the building has been prepared, taking into account solar energy use, heat reclamation, energy conservation, and operating cost. This shows the reduction in total energy demand for the enlarged structure using solar energy. An increase in building area from 12,400 square feet to 20,650, or better than 66.6%, will increase energy demand by only 353 KB/H or less than 26% of the present 1,343 KB/H.

DEHUMIDIFICATION/HEAT RECOVERY

Fresh air and dehumidification requirements will be met by using air to air energy recovery ("Z Duct"). The unit has a 3,000 cfm capacity which meets all code requirements during normal Swim School operations, i.e., building use by 125 or less people. During periods of high building usage (i.e., swim meets) additional fresh air will be introduced and heated if necessary by an existing fan and heating coil.

Performance of the energy recovery unit is based on the following:

a. Assume a year round efficiency of 68%.
b. Balanced flow exists - cfm exhausted = cfm supplied from outside.
c. The unit operates 8 hours per day, 365 days per year.
d. Exhaust air is constant at 80 degrees F., 69.5 degrees F. W.B., 92 grains (given the pool is maintained at 82 degrees plus, these values are conservative).

Monthly performance is shown below:

Month	Ambient °F	Operating Hours	#Cost	Heat Reclaimed
January	32	248	40.92	26.2×10^6
February	34	224	36.96	22.7×10^6
March	41	248	40.92	21.3×10^6
April	52	248	40.92	15.3×10^6
May	63	248	40.92	9.3×10^6
June	72	240	39.60	4.2×10^6
July	75	248	40.92	2.7×10^6
August	73	240	39.60	3.7×10^6
September	68	240	39.60	6.3×10^6
October	57	248	40.92	12.6×10^6
November	46	240	39.60	18.0×10^6
December	36	248	40.92	24.0×10^6
		2,920**	481.80	166.3×10^6

* $Q = (1.08)(\text{cfm})(\text{efficiency}) \Delta T$

** = This assumes unit operates only during actual building usage.

The heat recovery unit has two 1½ HP motors consuming 1.5 KW. Based on 2920 operating hours, the motors will consume 30.2×10^6 BTU annually. Therefore, the coefficient of performance for the heat recovery unit is 5.51. On a cost basis, the heat reclaimed would cost $969.66 annually if provided by gas at 3.79 per million BTU. At 5.5c per KWH, heat recovery costs $481.80 yielding a net savings of $487.85 annually.

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HEAT BALANCE SHEETS

MONTH	NEW BLDG. CONDUCTIVE HEAT LOSS MMBTU	NEW BLDG. HEAT REQUIRED MMBTU	ENTIRE DOMESTIC WATER LOAD MMBTU	ENTIRE POOL LOAD MMBTU	NET USABLE SOLAR ENERGY TO LOADS MMBTU	% SPACE HEAT PROVIDED BY SOLAR ONLY	SURPLUS ENERGY REMAINING FOR SUCCESSIVE LOADS MMBTU	ENERGY REQUIRED FOR BACK-UP ON NEW BLDG. SPACE HEAT MMBTU	SURPLUS ENERGY AFTER ALTERNATE LOAD #1 PROVIDED FOR MMBTU	ENERGY REQUIRED FOR BACK-UP ON ALTERNATE #1 MMBTU	TOTAL E. REQUIRED FOR ALTERNATE #1 DOMESTIC WATER HTG. MMBTU	ENERGY PROVIDED FOR ALTERNATE #2 FROM SOLAR ONLY MMBTU
JA.	16.9	55	28.3	115	30.2	.42	—	41.70	—	28.3	—	—
FEB.	14.5	47.6	25.6	115	38.4	.62	—	23.70	—	25.6	—	—
MAR.	12.0	39	28.3	115	60.2	1.00	9.2	—	—	19.1	9.2	—
APR.	6.2	20	27.4	115	63.9	1.00	37.7	—	10.3	—	27.4	10.3
MAY	2.0	6.7	28.3	115	71.1	1.00	62.4	—	34.1	—	28.3	34.1
JUNE	0	0	27.4	115	80.9	—	80.9	—	53.5	—	27.4	53.5
JUL.	0	0	28.3	115	83.0	—	83.0	—	54.7	—	28.3	54.7
AUG.	0	0	28.3	115	76.2	—	76.2	—	47.9	—	28.3	47.9
SEPT.	.6	2.0	27.4	115	61.8	1.00	59.2	—	31.8	—	27.4	31.8
OCT.	4.2	13.6	28.3	115	58.6	1.00	40.8	—	12.5	—	28.3	12.5
NOV.	9.4	30.8	27.4	115	33.7	.84	—	6.50	—	27.4	—	—
DEC.	15.4	50.5	28.3	115	24.8	.38	—	41.10	—	28.3	—	—
YR.	81	266	333	1376	682.8	233.9	449.4	113.00		128.70	204.6	244.8
TOTAL SPACE HTG. NEW BLDG.	347		61%			67.4%		32.6%		39%		

HEAT BALANCE SHEETS

MONTH	STACK HEAT EXCHANGER RECOVERY MMBTU	HEAT RECOVERY MMBTU	EXIST BLDG. SPACE HTG. & FRESH AIR LOAD MMBTU	HEAT RECOVERY STACK EXCHANGER PLUS NET SOLAR SUPPLIED MMBTU	GROSS COMBINED BLDG. LOAD NEW + EXISTING MMBTU	NET USABLE SOLAR ENERGY TO LOADS MMBTU	NUMBER OF HOURS OF BOILER OPERATION	NET BACK-UP ENERGY REQUIRED FOR GROSS COMBINED LOAD MMBTU	FUEL CONSUMED FOR BACK-UP ENERGY AS ABOVE @ .65 EFFICIENCY MMBTU	% FUEL SAVINGS FOR STACK HEAT RECOVERY	% FUEL SAVINGS FOR SOLAR CONTRIBUTION
JA.	53	26.2	250	83.2	465	302	265	397	530	11.4	6.5
FEB.	42.8	22.7	215	81.2	417.7	38.4	214	320.5	428	10.2	9.2
MAR.	37.8	21.3	177	98.0	371.3	60.2	189	283.1	378	10.2	16.2
APR.	24.8	15.3	90.5	88.7	259.1	63.9	124	185.3	248	9.6	24.7
MAY	14.6	9.3	30.0	85.7	182.0	71.1	73	109.2	146	8.0	39.0
JUNE	8.2	4.2	0	89.1	142.4	80.9	41	61.5	82	5.8	56.8
JULY	8.0	2.7	0	91.0	143.3	83.0	40	60.3	80	5.6	57.9
AUG.	9.0	3.7	0	85.2	143.3	76.2	45	67.1	90	6.3	53.2
SEPT.	12.4	6.3	9.4	74.2	154.4	61.8	62	92.3	124	8.0	40.0
OCT.	21.2	12.6	61.4	79.8	222.5	58.6	106	159.0	212	9.5	26.3
NOV.	35.8	18.0	139	69.5	321.6	33.7	179	268.8	358	11.1	10.5
DEC.	49.6	24.0	228	74.4	437.2	24.8	248	371.6	496	11.3	5.7
YR.	317.2	166.3	1200.3	1000	3260	682.8	1586	2266	3172	9.73	20.95

HEAT BALANCE SHEETS

MONTH	ALL THERMAL ENERGY DEMANDS	GAS AT .65 EFFICIENCY	ENERGY SAVINGS WITH ALL CONSERVATION EFFORTS	NET BTU REQUIRED	GAS TO SUPPLY NET BTU REQUIRED 65% EFFICIENCY	TOTAL FUEL SAVINGS ENERGY SAVINGS ÷ .65	% ENERGY SAVED	GROSS ENERGY SAVINGS WITH GAS $3.79/MMBTU	KWH TO COLLECT SOLAR ENERGY	KWH FOR STACK RECOVERY	DEHUMIDIFICATION HEAT RECOVERY	COLLECTION SYSTEM OPERATION HOURS
JA	465	715	109.4	355.6	547.1	168.3	24	637.86	353	13	744	186
FEB	418	643	103.9	314.1	483.2	159.8	25	605.64	319	11	672	168
MAR	371	571	119.3	251.7	387.2	183.5	34	695.47	412	9	744	217
APR	259	398	104.0	155.0	238.5	160	40	606.40	456	6.2	744	240
MAY	182	280	95.0	87.0	133.8	146.2	52	554.10	474	4	744	248
JUNE	142	218	93.3	48.7	74.9	143.5	66	543.87	456	2	720	240
JULY	143	219	93.7	49.3	75.8	144.2	66	546.52	471	2	744	248
AUG	143	219	88.9	54.1	83.2	136.8	63	518.47	473	2.2	720	248
SEPT	154	237	80.5	73.5	113.1	123.8	52	469.20	456	3	720	240
OCT	222	341	92.4	129.6	199.4	142.2	42	538.94	452	5.3	744	217
NOV	322	495	87.5	234.5	360.8	134.6	27	510.13	342	9.0	720	180
DEC	437	672	98.4	338.6	520.9	151.4	23	573.81	353	12.4	744	186
YR	3258	5008	1166.3	2091.7	3217.9	1794.3	43	6800.41	4972	79.1	8740	2618

HEAT BALANCE SHEETS

MONTH	$ TO OPERATE COLLECTION SYSTEM 5.5¢/KWH	$ TO OPERATE STACK RECOVERY SYSTEM 5.5¢/KWH	DEHUMIDIFICATION HEAT RECOVERY	$ TO OPERATE STORAGE-TO-LOAD SUBSYSTEM AT 5.5¢/KWH	% OF SOLAR CONTRIBUTION TO ENTIRE BLDG. LOAD	% OF STACK HEAT RECOVERY CONTRIBUTION TO ENTIRE BLDG. LOAD	% OF SOLAR + STACK RECOVERY CONTRIBUTION TO ENTIRE LOAD	COST OF TOTAL HEAT RECOVERY— SOLAR, HEAT WHEEL, STACK	NET ENERGY CONSERVATION SYSTEM SAVINGS: GAS-3.79/MMBTU, ELECTRIC-5.5/KWH—@.65	NET $ SAVINGS SOLAR SYSTEM GAS 3.79/MMBTU @.65 ELECTRIC 5.5/KWH @.65 only
JA	19.4	.72	40.92	3.85	6.5	11.4	17.9	64.89	572.97	153
FEB	17.5	.60	36.96	4.67	9.2	10.2	19.4	59.73	545.91	202
MAR	22.7	.50	40.92	3.85	16.2	10.2	26.4	67.97	627.50	324
APR	25	.34	40.92	3.96	24.7	9.6	34.2	70.22	536.18	345
MAY	25.9	.22	40.92	4.4	39.0	8.0	47.1	71.44	482.66	385
JUNE	25	.11	39.60	4.95	56.8	5.8	62.6	69.66	474.21	442
JULY	25.9	.11	40.92	5.06	57.9	5.6	63.5	71.99	474.53	454
AUG	25.9	.12	39.60	4.68	53.2	6.3	59.5	70.30	448.17	413
SEPT	25	.17	39.60	3.85	40.0	8.0	48.0	68.62	400.58	331
OCT	22.7	.29	40.92	3.58	26.3	9.5	35.9	67.49	471.45	316
NOV	18.8	.50	39.60	4.12	10.5	11.1	21.6	63.02	447.11	173
DEC	19.4	.68	40.92	3.02	5.7	11.3	17.0	64.02	509.79	122
YR	273.2	4.36	481.80	49.99	20.95	9.73	30.67	809.35	5991.06	3660

9 - MAJOR PROBLEMS AND RESOLUTIONS

A. The Revere collectors were found to cause a possible drainage problem. This problem would permit water to be trapped in the internal headers resulting in possible freezing and breakage of the collector absorber plate. The solution (at Revere's suggestion) was to pitch the collectors 1/4" per foot from right to left thus permitting complete drainage. Solar Energetics has completed the pitching procedure on the rack mounted and flush mounted collectors.

B. The collector pumps were installed originally sharing a common 3" suction line from the storage tank. This configuration caused a priming and starvation problem resulting in a situation whereby one or both of the pumps ran dry. The solution was to run a separate suction line from each pump to the storage tank. This solution has completely alleviated pumping problems.

C. The microcomputer based controller has had several start-up problems primarily caused by software or firmware associated problems. The software and firmware has been rewritten and installed so as to resolve the operational problems previously encountered. The addition of filters, heat sinks, and isolation transformers has eliminated the "crashing" problem, but the exact cause has yet to be determined. Jim Higgins of Higgins Energy Associates is currently working on finding the cause. A time initiated reset control was installed on the controller thus assuring a failsafe operation. This time control automatically resets the control every 5 minutes eliminating any possibility of spurious controller outputs (e.g. - collector drain-down interference, etc.).

10 - LESSONS LEARNED AND RECOMMENDATIONS

The primary lesson from an installer's standpoint is the difficulty of having complete confidence in the proper operation of a drain-down solar system in this climate. One can never be absolutely certain of complete drain-down, thus assuring freeze protection. We would not recommend a drain-down system for future solar installations, although we feel more than adequate provisions have been made to insure complete drainage.

The time required to install, test, and adjust a system of this size and complexity was underestimated. Coordination of the solar installation and the building construction should be carefully planned and coordinated to promote a reasonable sequence of completion with a minimum of of task repetition.

Each subcontractor performed their tasks well contributing to a successful project. Several compliments were made concerning the mechanical design. This led to simplified installation procedures. The maintenance that has been done was made easy through past experience and corresponding design concepts. Most of the installation effort was specialized allowing each subcontractor a specific task. This approach proved beneficial for the project completion.

The "think tank" created by our committee of construction manager, architect, engineer, solar consultant, and the various tradespersons successfully solved and adapted many difficulties encountered. This committee developed many new ideas and approaches applicable to future solar projects. We recommend this "design by committee" approach for an efficient and operational installation sequence, especially appropriate in solving field encountered installation problems.

11 - VERIFICATION STATEMENTS

A. Solar Energetics acting as the acceptance test plan administrator certifies that the solar system was installed per the as-built drawings and specifications.

B. All ATP provisions were met, ammended, or scheduled for later completion during the ATP meeting.

C. The solar design and architectural design of the Wilmington Swim School meet all the Interim Performance Criteria requirements as outlined in the original proposal.

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